A REVIEW OF THE BIOLOGICAL CONTROL OF INSECTS AND OTHER PESTS IN SOUTH-EAST ASIA AND THE PACIFIC REGION

by

V. P. RAO, M. A. GHANI, T. SANKARAN
AND K. C. MATHUR

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A REVIEW OF THE BIOLOGICAL CONTROL OF INSECTS AND OTHER PESTS IN SOUTH-EAST ASIA AND THE PACIFIC REGION

INTRODUCTION

In earlier volumes of this series, general reviews have been made of biological control work in Australia and Canada, and in the Ethiopean Region (Africa south of the Sahara) and of the extent to which Australia and New Guinea and Africa have been exploited as sources of biological agents for use in other areas. It is the aim of future volumes in this series to review similarly biological control work in other regions of the world, with special emphasis on the work done in the British Commonwealth, since such information is more readily available to this Institute. In selecting regions it is sometimes necessary to be rather arbitrary and not to follow natural zoogeographical boundaries. Thus in the first volume of the series, only Australian New Guinea was considered and not West Irian (at that time Dutch New Guinea). The present volume covers India and Pakistan (former undivided India), Burma, Ceylon, Malaysia, Thailand, Indonesia, the Philippines, Taiwan and the Pacific islands, but does not include Hawaii or New Zealand. In both these areas a great deal of useful biological control work has been done such as to merit separate treatment. It is hoped that a volume dealing with New Zealand will appear in the present series, and that an account of biological control in Hawaii will be included in a major work on biological control in the U.S.A. Compared with the accounts of work done in Australia and Canada, the material offered in this volume is in many parts unsatisfactory, since many of the attempts at biological control have simply consisted of obtaining and releasing material of a parasite or a predator which was readily available from some source and which might possibly, even though this possibility might be remote, be of value in controlling a pest in which an individual entomologist was interested at that time. Moreover, the documentation of such work has often been scanty and follow up investigations to determine the effect of any liberations of natural enemies have ofte not been carried out, thus leaving results unknown. Further, when recoveries of biological agents have been made following liberations, there has in many cases been little or no assessment of their economic value.

The method of biological control has particularly recently been subject to a certain amount of criticism on the grounds that claims of successful achievement are often based on very slim evidence, rather than on detailed quantitative assessment. This, in many instances, is unfortunately true and is clearly demonstrated in many of the attempts at biological control recorded in the following pages. However, it should be remembered that many of the introductions of natural enemies recorded here have been made with very little expenditure and hence with comparatively little planning and lack of really careful selection or investigation of the biotic agents involved. This is in contrast, in general, with the work described in the volumes on Australia and Canada. There are, of course, some notable exceptions in this region to this general statement. For example, biological control work in Fiji has for many years been very carefully planned and well financed, and the results obtained have been commensurate with the efforts, both in terms of work and money, expended. More recently, the possibilities of the biological control of the rhinoceros beetle, *Oryctes rhinoceros*, in the Pacific area have been investigated on a very thorough basis by the UN/South Pacific Commission team based in Samoa. But these and other similar exceptions only tend to emphasise the fact that in general in this area biological control work has been rather haphazard and ill-financed. The results have been commensurate with this, with a few major exceptions where comparatively little effort has resulted in a major success and very effective control of a pest, for example, the introduction from Java of *Macrocentrus homonae* into Ceylon against the tea tortrix, *Homona coffearia*. Also in this area there have been a number of instances where well-known natural enemies, which have been studied in detail in connection with problems elsewhere, have been introduced into various countries when similar pest problems have developed, *e.g.*, the use of

Rodolia cardinalis against cottony cushion scale, *Icerya purchasi*, and *Cryptolaemus montrouzier* against mealy-bugs. These might almost be called " standard " biological control measures in connection with certain pests, and because the potentialities of such natural enemies are well-known attempts to use them in connection with local outbreaks of pests when such arise are obviously common sense. However, whilst in some circumstances such biocontrol agents are very effective, under other different climatic or ecological conditions they may well be unsuitable, as may be seen from various such attempts described in this volume.

A notable difference between biological control work in this region, particularly in some countries, compared with that in many other parts of the world, is the emphasis that has been placed on the mass-breeding and releases of indigenous natural enemies rather than on the search for and introduction of exotic species which might be able to produce a better level of control of the pest population—without the effort involved in mass-release programmes, even if these latter were successful. It is noteworthy in this connection that with the numerous examples of such release programmes against a variety of pests which are cited here, there is no clear-cut example where repeated experiments have definitely shown that this method is economically sound. Yet proposals for use of this method continue, and in some areas parasites have been mass-bred and released against pests (e.g., *Nephantis serinopa*) for many years without any indication of control being obtained, and sometimes without even recoveries being made. There seems to be a strong tendency towards the attitude, which is fallacious, that if parasites are released, preferably in large numbers, then they *must* have some effect in controlling the pest, and that accurate assessment of results achieved is hardly worth while to confirm this self-evident fact. Whilst I certainly think that some well-thought-out, carefully evaluated, large-scale experiments on this method should be carried out, I am not convinced, and I have actually seen carried out in the field a number of the mass-release programmes cited here, that any of these operations are in fact giving economic control of the pests.

Whilst much of the data assembled here is scattered through the literature, and there may well be instances of biological control published in obscure journals (or not published at all), which are not cited here, several areas or pests have been well-documented, *e.g.*, publications on coconut pests in Fiji by Taylor, Tothill *et al.*, Baltazar's paper on biological control work in the Philippines and on introductions into Hawaii by Davis and Krauss, and Pemberton, etc., and the information given in these has been fully used and is gratefully acknowledged. However, in too many instances there is little recent information as to the results of a biological control campaign, or simple introductions. However, over the past ten years the Institute, with Stations in India and Pakistan, has been able to assist in biological control work in this area, and has endeavoured to obtain information as to what was being done, and results achieved in the field. In the areas where biological control work has been actively pursued, and Fiji is possibly the best example in this respect, outstanding successes have been achieved. This fact may well be conceded as being due to the fact that Fiji comprises a group of tropical islands where some claim biological control is more effective than in temperate and continental areas. It seems more pertinent, however, that Fiji has put more emphasis on biological control, and given strong financial support to the search for and introduction of really effective biocontrol agents against various pests, than possibly any other country covered here. This has been due no doubt to the initial spectacular successes achieved there with several coconut pests and weeds, and since " nothing succeeds like success", this has led to strong support for biological control work and adequate financing for this. It is hoped that this support for well-thought-out, long-term biological control programmes, as contrasted to the hit and miss tactics indicated with many of the attempts at biological control recorded here, and with the present awareness of the hazards involved in too much reliance on highly toxic modern pesticides, will be developed in other areas of the region. However, with the ever-increasing high-pressure salesmanship and persuasive measures adopted by competing pesticide companies in this, as in other areas, biological control usually finds it difficult to obtain the adequate financial support which in connection with many pest problems it genuinely deserves.

This book has been prepared as a joint effort by several members of the staff of the Commonwealth Institute of Biological Control, notably Drs. Rao, Sankaran and Mathur (Indian Station) and for information on Pakistan Dr. Ghani (Pakistan Station). Help has also been requested from a number of entomologists in different countries covered, since it is only from such specialists on the spot that it is possible to obtain up-to-date information and assessment of the value of past and recent attempts at biological control. Unfortunately the responses to these requests have been very varied, several of the entomologists contacted have made a very co-operative effort to give the necessary information—and I would like to thank n particular :

Dr. A. Catley, formerly Project Manager, UN/SPC Rhinoceros Beetle Project, Apia, Western Samoa; Mr. M. P. H. Soemarlan, National Research Institute of Health, Djakarta, Indonesia; Dr. U. B. M. Ekanayake, Coconut Research Institute of Ceylon, Lunuwila; Dr. D. F. Waterhouse and Mr. E. McC Callan, Division of Entomology, CSIRO, Australia, and Dr. Paul DeBach and Dr. Robert van den Bosch, University of California, U.S.A. The Division of Vector Biology and Control, WHO, Geneva, and the Departments of Agriculture and Public Health, Cook Islands, Hong Kong, Malaysia, Thailand and Viet Nam have helped with information relating to the biological control of pests of medical and veterinary importance.

On the other hand, some have completely ignored this request for assistance, and hence in these areas it is impossible to give information other than what appears in the literature consulted. It is probable that several attempts at biological control which have been made in this region have been overlooked, but every effort has been made, by consulting literature and by personal enquiry to make this work as comprehensive as possible, and it is hoped that it may form a useful basis for general consideration of the way in which biocontrol should be developed here in the future.

F. J. SIMMONDS

Director

Commonwealth Institute of Biological Control

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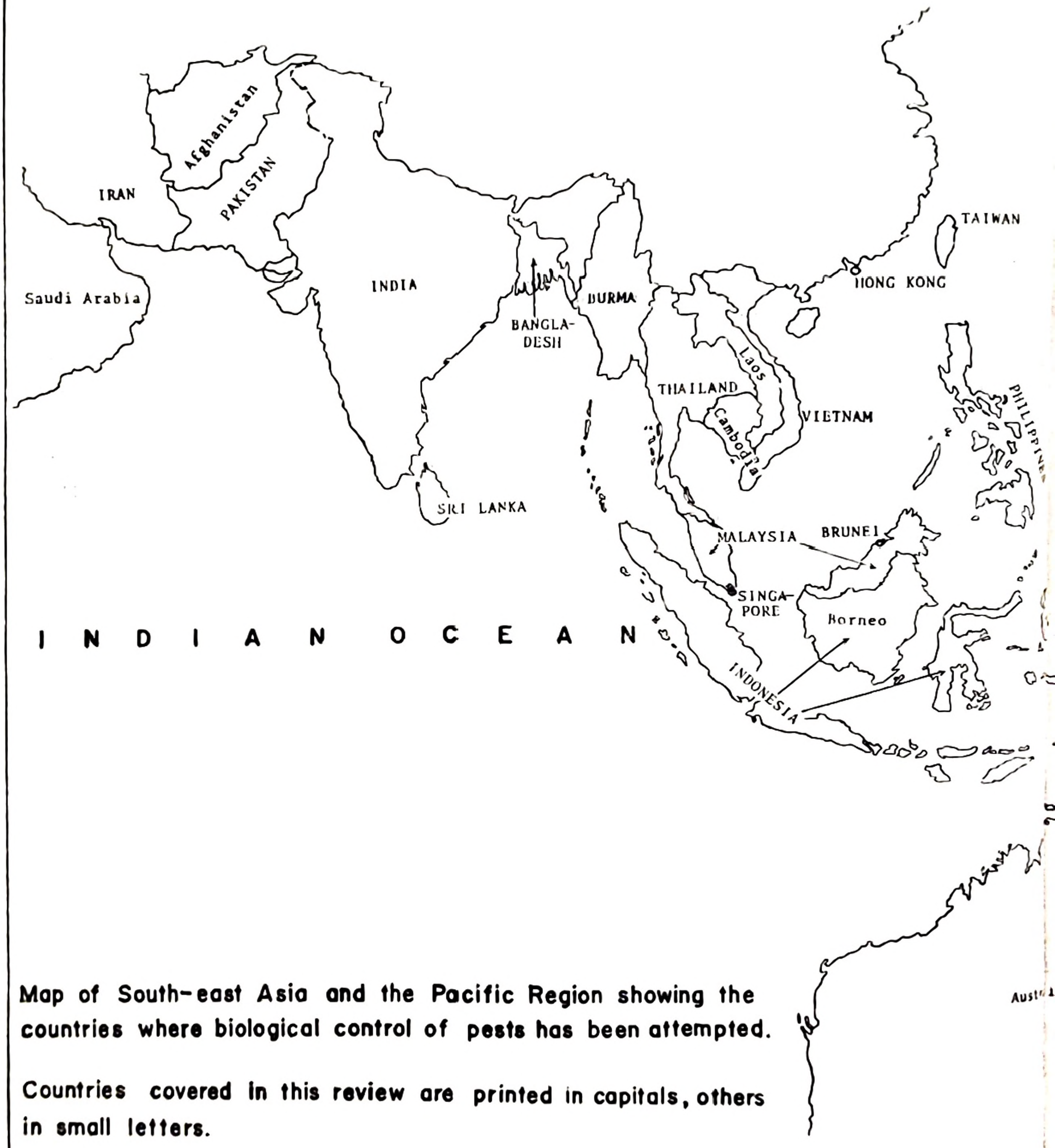
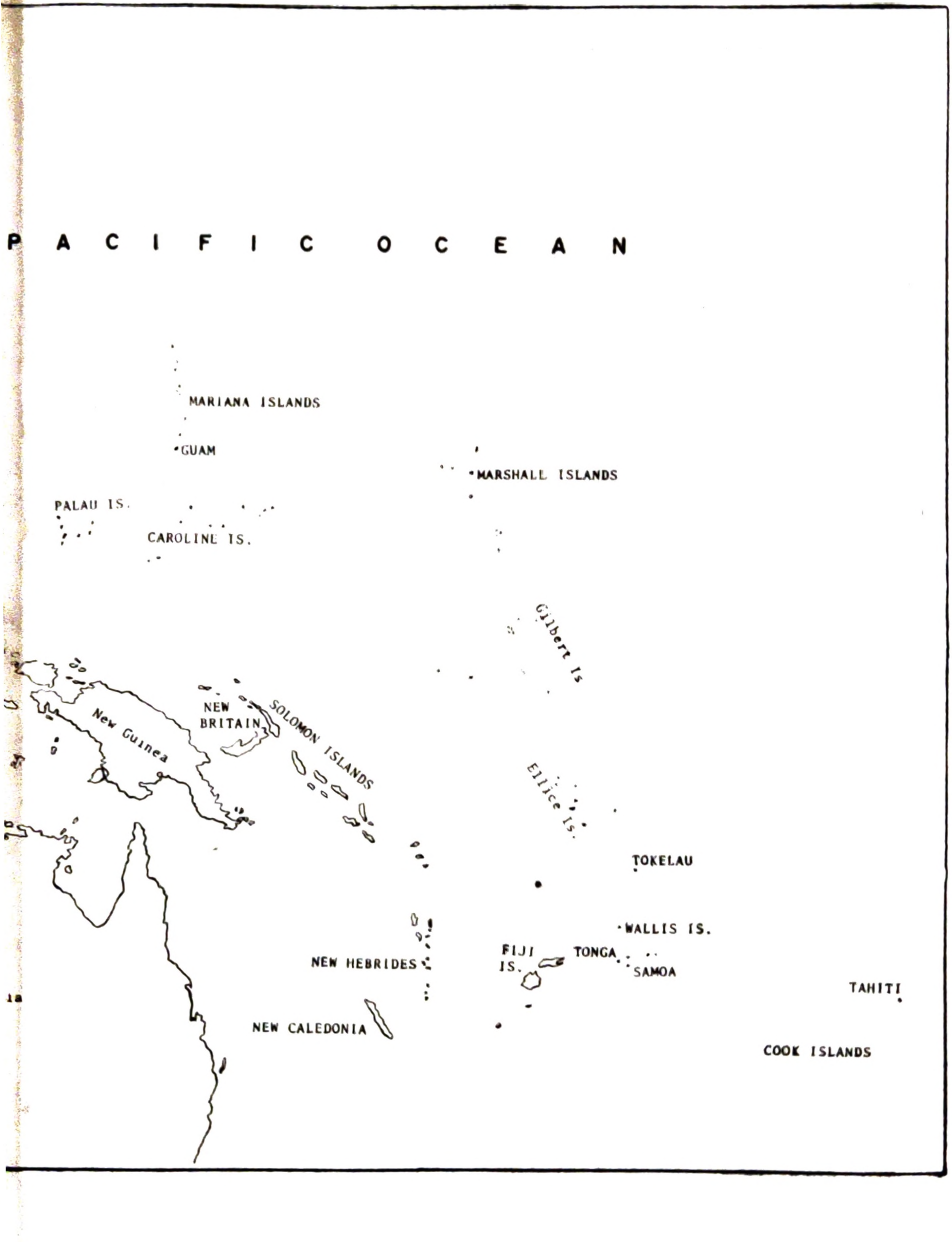


Map of South-east Asia and the Pacific Region showing the countries where biological control of pests has been attempted.

Countries covered in this review are printed in capitals, others in small letters.


PACIFIC OCEAN
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Gilbert Is
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TONGA
SAMOA
NEW HEBRIDES
TAHITI
NEW CALEDONIA
COOK ISLANDS
ia

PART 1

BIOLOGICAL CONTROL WORK IN SOUTH-EAST ASIA AND THE PACIFIC REGION

GENERAL

The first part of this Review deals with biological control of insects and other pests of agricultural, forestry, medical and veterinary importance. There are two additional sections, one on biological control of predators of the commercially important lac insect *Kerria lacca* (Kerr.) and the other on biological control of terrestrial and aquatic weeds. The agricultural pests are considered under the principal crops which they attack. The natural enemies introduced and the known results in each country or territory are reviewed separately.

A. PESTS OF AGRICULTURAL IMPORTANCE

Apple

(1) **Woolly aphid**—*Eriosoma lanigerum* (Hausmann) (Hem., Aphididae)

INDIA AND PAKISTAN

The woolly aphid *E. lanigerum* occurs in all the apple-growing tracts in the Indian subcontinent. It was probably accidentally introduced from England, as it was first noticed in Simla District, Himachal Pradesh (then in the Punjab) in 1909 on nursery stock imported from England (Rahman and Khan, 1941 *a*). Many local predators, especially Coccinellids, Syrphids and Chrysopids have been found attacking it. However, since these were not effective in controlling the pest in all the affected areas, a trial with exotic parasites was considered. A consignment of the Eulophid *Aphelinus mali* (Haldeman), a native of North America, established and controlling the aphid in England, was sent to Saharanpur (Uttar Pradesh) from the Farnham House Laboratory of the Imperial Institute of Entomology in England (Thompson, 1930). Several years later Singh (1942) stated that the parasite was not successful in the Kumaon Hills (Uttar Pradesh) owing to the activity of *Coccinella septempunctata* L. (Col., Coccinellidae), a local predator which killed off aphids, parasitised and unparasitised, and itself gave almost complete control (Lal and Singh, 1945), but it provcd extremely useful in the Kulu Valley (now in Himachal Pradesh). In 1936 the first shipment of *A. mali* was sent to Kulu from the Farnham House Laboratory, but all the parasite adults were dead on arrival. In 1937 four shipments received in succession yielded adult parasites. These were multiplied and the first batch of parasites was liberated in Raison (Kulu). The parasite became established and quickly spread to a number of infested orchards. It was found to be very effective in the Punjab (Rahman and Khan, 1941 *b*; Singh, 1942). During a survey for parasites of the San José scale *Quadraspidiotus perniciosus* (Comstock) in 1951 *A. mali* was found to have spread to the Kashmir Valley from the Kulu Valley, and was found to be very active in this area (Narayanan, 1957). It was also released at Simla and reported to be well-established and successfully controlling the pest there (Rahman, 1939). In mid-April 1940 *A. mali* was introduced from Kulu into the apple-growing areas at Coonoor in the Nilgiri Hills (South India). In 1944–45, even though parasitism ranged from 44·5 to 100%, the parasite was not able to cope with the rapid multiplication of the pest, especially in the latter's swarming stages, and hence spraying with insecticides, such as nicotine sulphate, *Lobelia* and *Thevetia* extracts, had to be undertaken to supplement biological control. However, releases were continued and the parasite population was built up by sustained efforts. This successfully kept the aphid under control at the Pomological Station, Coonoor, where no further chemical control was found necessary.

The parasite was sent to Kodaikanal and Shembaganur in South India in 1943 and became established. In subsequent years parasitism ranged between 70% and 82·5% from July to December, although the pest increased rapidly from January each year. Therefore the authorities again resorted to insecticides, which adversely affected the parasite (Adm. Reps., Government Entomologist, Madras, for 1944–46, 1949–52).

In view of the severe infestation of the woolly aphid on apple in the Lachung Valley, North Sikkim (Rao, 1960), and following a request from the Sikkim Government, efforts were made by the CIBC Indian Station to introduce some exotic strains of *A. mali* better adapted to the climate of these high altitudes. The Canadian and South African strains of *A. mali*, together with that already established in the Nilgiris, were released in sleeves on infested apple twigs at Lachung and also directly in the orchards. Whilst it was successfully established inside the sleeves, it is uncertain what occurred later owing to the closure of the sub-station at Lachung during the Chinese/Indian disturbances.

A. mali was also sent to Shillong (Assam) from Coonoor in April, June and October, 1963 and from Kulu in October 1963. Periodic releases were made on infested branches, both sleeved and exposed, where woolly aphid infestation was heavy. By July and August many mummified aphids were observed on the exposed branches. In 1964 further releases of *A. mali* were made and the parasite was firmly established (Chacko, 1967).

Until recently *A. mali* was not known to attack any other aphid in India. Sankaran (1967) reported that it was reared from *Aphis gossypii* Glover (Hem., Aphididae) infesting the aquatic weed *Bacopa monnieri* Pennell at Bangalore. Later, the parasite was reared from *Aphis spiraecola* Patch at Shillong and from *Myzus persicae* (Sulzer) at Bangalore (Ramaseshiah and Dharmadhikari, 1969). It is possible, however, that the *A. mali* associated with the different hosts are actually sibling species.

(2) **San José scale**—*Quadraspidiotus perniciosus* (Comstock) (Hem., Coccidae)

INDIA AND PAKISTAN

The San José scale is a serious pest of apples in North-western India and in West Pakistan and is also recorded on poplars and willows, peach and other deciduous fruit-trees (Rao and Rao, 1960). Pruthi and Rao (1951) mentioned some 50 host-plants. *Prospaltella perniciosi* Tower (Hym., Eulophidae) was imported from California in 1953 but this was unsuccessful. In 1958 it was again imported by the CIBC Indian Station. In 1960 three other strains of this parasite were imported into India—Illinois and Chinese strains from Switzerland and a Russian strain from France. An Aphelinid, *Aphytis diaspidis* How., was also introduced from California. These two parasite species have been used in the biological control of the pest in the north-western states of India and Pakistan.

The Russian strain has been the most successful in Himachal Pradesh where 89% parasitism was recorded in 1961. The Californian and Chinese strains have also become established. Parasitism by the former in combination with *A. diaspidis* was 86·5%, and by the latter 8%. This initial low parasitism by the Chinese strain was probably due to the very small number of parasites released in comparison with the other strains (Jolly, 1961–62). In Kashmir the Russian and Chinese strains gave 43·9% and 58·8% parasitism, respectively, in 1964 and 78·9% and 62·9% in 1965. In 1965 the Californian and Illinois strains gave a maximum of 35·7% and 50·2% parasitism, respectively (unpublished report of Government of Jammu and Kashmir, 1964–65). From August 1967 to July 1968 the Californian strain gave 66·8% parasitism at Shalimar and 61·7% at Nunar; that by the Russian strain was 59·8% at Wadora, 80·5% at Malatia, 80·6% at Lathapora, 70% at Awantipora and 65·1% at Hael-Jawaharnagar. Parasitism by the Chinese strain was 69·7% at Karalpora and 65·3% at Bachpora (unpublished report of Government of Jammu and Kashmir, 1967–68). *P. perniciosi* has also become established in the Kumaon Hills of Uttar Pradesh where, following the release of the American and Chinese strains, the population of the scale decreased by 95·73% and 94·78%, respectively (Sahai and Joshi, 1965).

In 1961–62 over 13,000 adults of *P. perniciosi* and 2,300 of *A. diaspidis* were released in West Pakistan (Murree Hills) by the CIBC Pakistan Station. The former was recovered soon after release but seemingly could not compete with *Aphytis* sp. (*proclia* group), a local parasite which is quite abundant. *A. diaspidis* failed to become established.

Also from California a Japanese strain of *Aphytis* sp. near *diaspidis* How. was recently introduced and nucleus cultures have been supplied to Kashmir and Himachal Pradesh for laboratory multiplication. From the CIBC West Indian Station a Coccinellid, *Chilocorus kuwanae* Silv. (origin Japan) and a Nitidulid, *Cybocephalus gibbulus* Erickson (origin Japan) were also imported. *C. kuwanae* was liberated in orchards in Kashmir, Himachal Pradesh and Uttar Pradesh and in the Murree Hills. *C. gibbulus* was liberated in orchards in Kashmir. *Aphytis* sp. nr. *diaspidis* was recovered from Sumbal and Wadora in Kashmir. Average percentages of parasitism in these localities during the period August 1967 to July 1968 were 68·6% and 61·3%, respectively (unpublished report of Government of Jammu and Kashmir, 1967–68). Other species have not as yet been recovered.

An indigenous predator, *Chilocorus circumdatus* Schönh., occurring in South India, was also bred at Bangalore and sent to Uttar Pradesh for trial against San José scale. No recovery has yet been made.

In 1967 some 430 adults of *Pentilia insidiosa* Muls. (Col., Coccinellidae) obtained from Trinidad through the CIBC West Indian Station were released at Abbottabad (West Pakistan). It started breeding, and immature stages of the predator were observed soon after releases. However, it could not survive the following winter.

(3) **Codling moth**—*Cydia pomonella* (L.) (Lep., Olethreutidae)

PAKISTAN

The codling moth is a serious pest of apples, pears and quinces in the western hilly areas of West Pakistan. In the summer of 1942 two consignments of *Ascogaster quadridentata* Wesm. (Hym., Braconidae) and *Ephialtes caudatus* (Ratz.) (Hym., Ichneumonidae) were obtained from the Imperial Parasite Service, Belleville, Ont., Canada (now Commonwealth Institute of Biological Control) and released. The parasites failed to breed, probably because the climatic conditions were unfavourable (Janjua and Chaudhry, 1958).

Banana

(4) **Banana weevil-borer**—*Cosmopolites sordidus* (Germ.) (Col., Curculionidae)

COOK ISLANDS

The Histerid predator *Plaesius javanus* Er. (origin Java) was introduced from Fiji, 756 beetles were liberated in Rarotonga in 1938 and another 376 in 1940. Although *Plaesius* is now well established it does not effectively control the weevil-borer (unpublished report, Department of Agriculture, Cook Islands).

FIJI

C. sordidus is a most serious pest of bananas in Fiji. To control it *P. javanus* was introduced from Java in 1913–14. Five thousand beetles were sent to Fiji in moist soil without food, of which 3,500 survived. These were liberated in lots of 500 in seven plantations (Jepson, 1914). Larvae and pupae of the predator were seen in the field several months later. In 1918 a further shipment of 163 beetles was received from Java. *P. javanus* was recovered in the field in 1921 and it subsequently became well established on the island of Viti Levu (Anon, 1924; O'Connor, 1950 *b*). Simmonds (1935 *c*) reported that damage to bananas by *C. sordidus* had become markedly reduced on one island. However, a later report mentioned that *Plaesius*, in general, gave only partial control (Pemberton, 1954).

GUAM AND PALAU ISLANDS

P. javanus was obtained from Fiji in 1947 and released on Guam. It was reported in 1949 to be established on the island. In 1953 a species of *Hololepta* (= *Leionota*) (Histeridae) was received from Trinidad and released on Guam and on several of the Palau islands. It is not known whether this has become established (Gardner, 1958). Peterson (1956 *c*) mentions the introduction of *Hololepta minuta* Eric. and *H. quadridentata* (F.) from Trinidad into Guam in 1953 and 1954. Although one adult was recovered in 1954, its establishment seems uncertain.

Over 100 adults of *Dactylosternum hydrophiloides* Macl. (Col., Hydrophilidae) were received from Malaya in 1948 and liberated on the island of Koror (Palaus). It is not known whether this predator has become established (Gardner, 1958).

TAHITI

In 1937, 800 *P. javanus* were shipped from Fiji to Tahiti for field trials. It was reported that there was less damage by the pest to bananas after the introduction of this predator (Lever, 1938 *c*, *d*).

TAIWAN

P. javanus was also imported into Formosa (Miwa, 1938), but the results of field liberations are unknown.

(5) **Banana scab moth**—*Nacoleia octasema* (Meyr.) (Lep., Pyralidae)

FIJI

This pest is fairly widespread in Fiji, and whilst most of the damage consists of blemishes on the skin, loss of fruit occurs when the attack is severe. Simmonds (1929 *a*) introduced *Trathala flavo-orbitalis* Cameron (= *Cremastus hymeniae* Vier.) (Hym., Ichneumonidae), *Microbracon omiodivorum* Terry (Hym., Braconidae) and *Brachymeria obscurata* Walk. (Hym., Chalcididae) from Hawaii where they attack *Nacoleia blackburni* Butl. and five allied species on coconuts and bananas. Two hundred adults of the Braconid were brought in and 150 of them liberated in Tamavua. After unsuccessful attempts to breed the rest in the laboratory, they were liberated. Only 16 *Trathala* were introduced and their breeding was unsuccessful. Twenty-five of the Chalcids were used for breeding in captivity and attacked the pupae of *N. octasema* as well as of the cotton pest *Sylepta*. However, this culture was subsequently destroyed since there was already found to be 20 to 25% parasitism by a local Chalcid and it was thought unlikely that *B. obscurata* would materially increase this, besides there was the danger of its attacking *Ptychomyia remota* Aldr., an important Tachinid parasite of *Levuana iridescens* B.-B (Lep., Zygaenidae). Taylor (1933) shipped a small consignment of *Cremastus* sp. from Java to Fiji. By the end of November 1933, over 4,000 adults had been bred (reproduction is parthenogenetic) from the original 24 females obtained from Java, and released in the field. Evidence of breeding in the field was found in Tamavua in the Suva District (Simmonds, 1933 *a*). During 1934 the parasite was bred further and 6,030 females were liberated. No recoveries were made till late 1934 (Simmonds, 1935 *c*) and nothing is known as to its establishment thereafter.

O'Connor (1960 *b*) refers to further introductions. He spent two months in New Britain with a view to sending sufficient stocks of the Tachinid *Argyrophylax* (*Bactromyia*) *fransseni* Bar. He found it difficult to induce the parasite to mate in captivity. *Goniozus triangulifer* Kieff. (Hym., Bethylidae) was found to attack the scab-moth larva. In 1953 it was taken to Fiji, bred and 12 males and 50 females were liberated. There is no evidence of its establishment. In the same year 24 adults of *A. fransseni* reared from a shipment sent by G. S. Dun were liberated. In 1958 a few *A. fransseni* and *G. triangulifer* were sent by R. W. Paine from New Britain, but their breeding was unsuccessful. Paine also discovered 7 species of primary parasites, of which the most promising was a polyembryonic Encyrtid, *Pentalitomastix nacoleiae* Eady. This parasite was received in 1957, bred on *N. octasema* in the insectary and about a million were liberated, but only a dozen parasitised prepupae were recovered from the field, which produced only male parasites. The parasite failed to become permanently established, possibly because it does not frequent the banana plant (O'Connor, 1960 *b*).

An egg-larval parasite, *Chelonus striatigenas* Cam. (Hym., Braconidae), was found by Paine in Flores and Timor (Indonesia). During January and February 1960 five shipments of this parasite bred in Java were sent. From these 250 males and 350 female *Chelonus* adults emerged. Most of these were liberated, while the remainder were used for laboratory breeding (O'Connor, 1960 *b*). Paine (1960) also sent a Braconid from New Britain, an Ichneumonid an *Apanteles* sp. (Braconidae) and *Sisyropa* sp. (Dip., Tachinidae) from Bougainville and the last species also from the British Solomon Islands. Only *C. striatigenas* is known at present to be established at its two main liberation sites, up to 70% parasitism having been recorded (O'Connor, 1964).

(6) ***Spodoptera litura*** (F.) (Lep., Noctuidae)

GUAM

Larvae of *S. litura* were found causing considerable damage to leaves of bananas. In 1936 a colony of *Telenomus nawai* Ashm. (Hym., Scelionidae) was received from Hawaii where it is an effective egg-parasite of *Spodoptera exempta* (Walk.). This was successfully bred on *Spodoptera* eggs and distributed in various districts of the island. Later, parasitised eggs were collected at several places indicating its establishment. It also attacked the eggs of *Spodoptera mauritia* (Boisd.) (Swezey, 1940).

Cabbage

(7) **Diamond-back moth**—*Plutella xylostella* (L.) (= *maculipennis* (Curt.)) (Lep., Plutellidae)

Attempts to control *P. xylostella*, a pest of cabbage and other crucifers, have been made in Ceylon, Fiji, Hong Kong, India, Indonesia and Thailand.

CEYLON

A consignment of *Thyraeella collaris* Grav. (Hym., Ichneumonidae), a larval-pupal parasite, was sent from India to Ceylon in 1965 but it could not be bred in the laboratory there.

FIJI

In Fiji *P. xylostella* is gaining in importance with increasing cultivation of crucifers. It is often associated with *Crocidolomia binotalis* Zell. (Lep., Pyralidae), which may also be a serious pest. *T. collaris* (originally from Europe) was introduced against it from New Zealand in 1943. The parasite was bred and 240 individuals were liberated (Lever, 1943 *b*). It is not known whether it has become established.

HONG KONG

During 1968 the larval parasites *Apanteles plutellae* Kurdj. (Hym., Braconidae), *Macromalon orientale* Kerr. (Hym., Ichneumonidae) and *Nythobia* sp., and the pupal parasite *Tetrastichus sokolowskii* Kurdj. (Hym., Eulophidae) and *T. collaris* were sent by the CIBC Indian Station to Hong Kong. *M. orientale* and *T. sokolowskii* were released in the field but there is as yet no indication of their establishment.

INDIA

A culture of a nuclear polyhedral virus of *P. xylostella* has recently been obtained by the CIBC Indian Station from the Insect Pathology Unit, Oxford. It has been multiplied on its natural host and the preliminary studies under field conditions have given encouraging results.

INDONESIA

Diadegma cerophagus Grav. (= *Angitia cerophaga* (Grav.)) was introduced into Indonesia from Holland in 1928 but failed to become established. Since the difference in climate was thought to be a factor responsible for its failure, a fresh introduction was made in 1950 from New Zealand. The parasite became established near Patjet, where parasitism in 1951–52 averaged 72–82%. Liberations were also successful in other areas in Java and Sumatra except in areas where cabbage was heavily treated with insecticides. Wherever the parasite became established, the reduction in the *Plutella* population was considerable (Vos, 1953).

Oka (1957) reported difficulty in controlling *P. xylostella* on cabbage in parts of Indonesia. In the laboratory, experiments were therefore conducted with *Bacillus thuringiensis* Berliner obtained from Hawaii. It was cultivated on agar from growing seeds of *Phaseolus aureus* Roxb. to which 2% glucose was added and a powdered mass prepared from the dried spores. Encouraging results were obtained in the field tests (Dresner, 1958).

THAILAND

A. plutellae, *M. orientale*, *T. collaris*, *T. sokolowskii* and *Brachymeria* sp. (Hym., Chalcididae) were sent to Thailand from India in 1965 by the CIBC Indian Station. These could not be bred in the laboratory there and apparently no field releases were made.

Cocoa

(8) **Cocoa mealy-bug**—*Planococcus lilacinus* (Ckll.) (Hem., Coccidae)

CEYLON

Unidentified hymenopterous parasites were obtained from the Philippines for trial against *P. lilacinus*. These gave very poor results with the local host under laboratory conditions (Fernando, 1954).

(9) **Cocoa fruit-moth**—*Acrocercops cramerella* Sn. (Lep., Gracillariidae)

INDONESIA

In Java the use of native parasites against *A. cramerella* has been suggested. Roepke recommended a method of control by which cocoons of the moths should be collected and the parasitised ones segregated (the others destroyed). Any hyperparasites emerging should naturally be destroyed and the primary parasites liberated in infested fields. Such liberations should be carried out every sixth day in each plantation. Two of these Ichneumonid parasites have been identified as *Hemiteles* spp., the third as *Goryphus* sp. The method appears to be laborious but was said to work best on a plantation of moderate size (Roepke, 1912, 1914).

Citrus

(10) **Orange spiny black-fly**—*Aleurocanthus spiniferus* (Quaint.) (Hem., Aleurodidae)

GUAM

This pest was first recorded on Guam in 1951, and subsequently spread rapidly to all parts of the island except the north, where it was found in 1953. *Prospaltella smithi* Silv. (Hym., Eulophidae). *P. clypealis* Silv., *P. opulenta* Silv., *Eretmocerus serius* Silv. (Eulophidae) and *Amitus hesperidum* Silv. (Eulophidae) were introduced from Mexico in 1952. The numbers liberated were: 17,000 *P. smithi*, 30 *P. clypealis*, 88 *P. opulenta*, 13,500 *E. serius* and 28,100 *A. hesperidum*. These parasites were earlier successfully introduced from South-East Asia into Mexico against *A. woglumi* Ashby on citrus. *P. smithi* and *A. hesperidum* became established on Guam and provided 80–95% parasitism, which was sufficient for commercial control. Of the two, *P. smithi* was predominant. *E. serius* was recovered on several occasions during 1953, but not thereafter. It is possible that the pronounced dry season which occurs in Guam each spring is responsible for its failure. *P. clypealis* and *P. opulenta* have not been recovered (Peterson, 1956 *d*).

(11) **Fluted scale**—*Icerya purchasi* Mask. (Hem., Coccidae)

INDIA

This insect was probably introduced on imported orchard stock or flowering plants from Ceylon and it spread to cultivated wattles, rose-bushes and citrus. An account of its biological control by the introduced Coccinellid predator *Rodolia* (*Vedalia*) *cardinalis* (Muls.) is given on pp. 38–39.

Coconut

(12) **Coconut stick insect**—*Graeffea crouanii* (Le Guillou) (Orth., Phasmatidae)

FIJI

G. crouanii is a widespread pest of coconut palms in many islands of the South Pacific. A serious outbreak occurred from 1958 to 1961 on the Taveuni Island in the Fiji group. Since there were no known parasites of the nymphal stages a search for parasites of other palm-feeding Phasmatids was made in Melanesia. Two species of Tachinids, *Mycteromyiella laetifica* (Mesnil) and *M. phasmatophaga* Crosskey, appeared to be important factors in the control of *Ophicrania leveri* Gunth. in the Solomon Islands. Between October 1963 and March 1964 some 960 puparia of *M. laetifica* were shipped to Fiji, where about half of them were used for breeding trials and the rest released on Taveuni. This Tachinid could be reared on *G. crouanii* in captivity but "could not be maintained". A further outbreak of the stick-insect occurred during 1965, which yielded no evidence of establishment of *M. laetifica*. Material of *M. phasmatophaga* was insufficient for shipment to Fiji. Small numbers of *O. leveri* parasitised by the two Tachinid species were released on Savo Island in the Solomons, where the parasites appeared to be absent. It was thought that if these Tachinids became established on Savo it would facilitate their shipment from there to Fiji and other Pacific islands. Samples collected six months later gave no indication of their establishment (Paine, 1968).

In 1956 eggs of the Phasmatid *Ctenomorphodes tessulata* Gray parasitised by the Cleptid wasp *Myrmecomimesis rubrifemur* Riek were received from Australia. From these eggs 33 male and 29 female parasites emerged but attempts to breed this parasite on *G. crouanii* were unsuccessful (O'Connor, 1960 *b*).

(13) **Coconut grasshopper**—*Sexava nubila* (Stal) (Orth., Tettigoniidae)

INDONESIA

S. nubila, *S. coriacea* L. and *S. karnyi* Leefmans are serious pests of coconut in Talaud Islands in the north of Indonesia. Attempts to control them by introducing egg-parasites from other areas have been made between 1925 and 1940.

An unidentified Encyrtid egg-parasite was introduced from Amboina into Karakelong, the largest island of the Talaud group and after one year the parasite was found to have become established. Another Encyrtid egg-parasite, *Leefmansia bicolor* Waterston, and a Trichogrammatid *Doirania leefmansi* Waterston were also introduced from Amboina into the Talaud Islands. These have proved effective. When the wild host plants of *Sexava* in the coconut plantations were replaced by cocoa, cloves and *Centrosema pubescens* Benth. (grown as a green manure) the *Sexava* females laid their eggs in these plants and egg parasitism by *Leefmansia* rose to 85–95 per cent (Leefmans, 1927; Voute, 1937; Kalshoven, 1950; Franssen, 1954).

A Scelionid, *Prosapegus atrellus* Dodd from New Guinea and an *Eupelmus* sp. (Eupelmidae) from Java were also introduced but without success (Kalshoven, 1950).

(14) **Coconut-scale**—*Aspidiotus destructor* Sign. (Hem., Coccidae)

The coconut-scale *A. destructor* is a major pest in almost all coconut-growing countries of the world. Distribution records in the area covered by this review include Ceylon, Fiji, India, Indonesia, Malaysia and the Philippines (Menon and Pandalai, 1958).

FIJI

In Fiji *A. destructor* was first reported as a pest of banana and later became a serious pest of coconut. During 1920–25 two Chalcid parasites, *Aphytis chrysomphali* (Mercet) and *Aspidiotiphagus citrinus* (Craw.) occurring in Tahiti (Society Islands), were introduced (Simmonds, 1921) and liberated on Viti Levu, Moturiki, Ovalau (in 1920); Gan, Batiki, Nairai (1924); Vanua Levu (1923, 1924), Wakaya, Koro, Moala and Kadavu (Taylor, 1935). The first liberation of *A. chrysomphali* was made at Nasinu in 1920 and it became established and spread rapidly. *A. citrinus* was first liberated on Moturiki in the same year and later on Ovalau where it parasitised up to 90% of the scales. Although by 1927 these parasites were widely distributed and responsible for high degree of parasitism locally they did not exercise sufficient control of the pest to prevent its spread and extensive damage to the crop. Therefore, *Comperiella unifasciata* Ishii (Hym., Encyrtidae), *Spaniopterus crucifer* Gah. (Encyrtidae), *Casca parvipennis* Gah. (Aphelinidae), *Scymnus* sp. (Col., Coccinellidae) and *Aleurodothrips fasciapennis* Frankl. were introduced from Java in 1927, together with a further stock of *A. chrysomphali* from Java (Taylor, 1935). Some 250 adults of *A. chrysomphali*, 104 *C. unifasciata*, 1,000 *C. parvipennis* and 1,360 adults of *S. crucifer* were liberated. Although all four parasite species were recovered at Nukulau a month later their establishment was not permanent. Taylor (1935) attributed this to the rapid spread of Coccinellids imported from Trinidad (see below). Some 4,000 *Scymnus* sp. were liberated in 13 localities. Recoveries of this Coccinellid made a year later indicated that it had definitely become established. However, it did not bring about satisfactory control of the scale. *A. fasciapennis* was also liberated in large numbers. Many years later it was found to have become established (O'Connor, 1960 *b*).

In view of the failure of these Javanese parasites and predators, introduction of Coccinellids from the West Indies was proposed by Dr. J. D. Tothill. *Cryptognatha nodiceps* Mshl., *C. simillima* Sic., *Azya trinitatis* Mshl., *Pentilia insidiosa* and *Scymnus aeneipennis* Sic. were received from Trinidad. A total of 5,680 *C. nodiceps*, 1,000 *C. simillima*, 25 *A. trinitatis* and 330 *S. aeneipennis* were liberated in different localities. *P. insidiosa* could not be bred under Fijian conditions. *C. nodiceps* proved to be the most effective species and soon became well established to such an extent that through its activity not a single new outbreak of the scale occurred from 1928 to 1934 on any of the islands where it was common (Taylor, 1935). *C. simillima* also became well established and although it could not multiply as prolifically as *C. nodiceps*, it did exert significant control over the scale. *S. aeneipennis* was certainly established at least temporarily. It probably failed as a result of competition with the superior *C. nodiceps* which suppressed the scale rapidly (Taylor, 1935). *A. trinitatis* did not become established.

GUAM

Attempts to introduce and establish the Coccinellid *Lindorus lophantae* (Blaisd.) (origin Australia) from California and Hawaii were unsuccessful (Vandenberg, 1928).

INDONESIA

In 1928 *Chilocorus politus* Muls. (Col., Coccinellidae) was introduced into Sangi and Boroko (N. Celebes) from Java. A total of 206 adults at Sawang and Kalasoege on the north coast of Sangi, 100 at Taroena, 200 at Boroko and 200 at Nanonka were liberated. The predator became established but failed to exercise significant control of the scale (Reyne, 1948). The Encyrtid *C. unifasciata* was introduced into Sangi from Java in 1927 against *A. d. rigidus* Reyne although it already occurred in South Celebes. Several introductions were made and the parasite became established but again gave no effective control (Reyne, 1947).

In 1934 *Comperiella bifasciata* How., *A. citrinus* and *C. politus* were shipped to Bali from Java to control the coconut-scale. *A. citrinus* became established and increased in numbers to such an extent that by 1936 the scale was fully controlled by it (Voute, 1937).

NEW HEBRIDES

A. destructor was first observed on the island of Vaté in the New Hebrides in 1962. Small numbers of *C. nodiceps* from Fiji (origin Trinidad), *A. trinitatis* from Trinidad and *Pseudoscymnus* sp. from the Caroline Islands were released in 1964 but none of them became established. In the same year *Rhizobius pulchellus* Montrouzier (Coccinellidae) was found, for the first time, preying on *A. destructor* in one locality on Vaté. Since this Coccinellid appeared to be a very effective predator 93,030 adults were collected and released in other parts of the island in groups of 300–3,000 according to the severity of attack. The predator afforded spectacular control of the scale. *R. pulchellus* is a native of New Caledonia and on Vaté Island it was previously mistaken to be *Lindorus lophantae* (Cochereau, 1969).

PAKISTAN

In 1968 some 30 adults of *A. trinitatis* and 1,860 *C. nodiceps* from Trinidad (through CIBC West Indian Station) were released by the CIBC Pakistan Station in the Karachi area where coconut had recently been planted. Neither predator was established.

(15) **Red coconut-scale**—*Furcaspis oceanica* (Ldgr.) (Hem., Coccidae)

SAIPAN ISLAND (MARIANAS)

The red coconut-scale appears to be native to the Pacific Islands, where it occurs in several coconut-growing areas. Investigations in the Western Carolines in 1948 revealed that the scale is controlled by the Encyrtid *Anabrolepis oceanica* (Doutt). A shipment of this parasite was sent from there to Saipan in the same year. It is doubtful whether it has become established in the Marianas (Gardner, 1958).

(16) **Florida red scale**—*Chrysomphalus ficus* Ashm. (= *aonidum* auct.) (Hem., Coccidae)

PHILIPPINES

In 1930 *Comperiella bifasciata* was introduced from Japan for trial against *C. aonidum*, a serious pest of coconut in the Philippines. The parasite was liberated in Cebu and Iloilo and was reported to have become established. Baltazar (1963), however, considers *C. bifasciata* to be a native parasite as she found a slide-mounted specimen of this parasite in the U.S. National Museum collected from the Philippines in 1929, even before its introduction from Japan.

Azya trinitatis and *Cryptognatha nodiceps* were introduced from Trinidad in 1967, and *Lindorus lophantae* was obtained from Bermuda in 1968 through the CIBC West Indian Station.

(17) **Green coconut-bug**—*Amblypelta cocophaga* China (Hem., Coreidae)

SOLOMON ISLANDS

A. cocophaga causes injury to coconut inflorescences in the Solomon Islands. In feeding it punctures both female flowers and young nuts, resulting in the fall of flowers and immature nuts.

A Tachinid, *Pentatomophaga bicincta* de Meij., which attacks *Amblypelta lutescens* (Dist.) in Queensland, was introduced in 1938–39 but this was unsuccessful (Phillips, 1956).

Another Tachinid, *Trichopoda pennipes* F., a parasite of Pentatomid and Coreid bugs, was introduced from Florida (U.S.A.) in 1950 through the CIBC West Indian Station, Trinidad. The fly was initially shipped to Fiji and bred there through several generations.

Under favourable weather conditions 205 mated females and 74 young males were released in an area on Malaita (O'Connor, 1950 *a*). Later it was reported that there was no evidence of establishment of the parasite (O'Connor, 1954).

In 1937–38 *Ooencyrtus* sp., *O. malayensis* Ferriere (Hym., Encyrtidae), *Hadronotus homoeoceri* Nixon (Hym., Scelionidae) and an *Anastatus* sp. possibly *dasyni* Ferriere (Hym., Eupelmidae), all parasitic on eggs of the Coreids *Homoeocerus lucidus* Walk. and *Dasynus manihotis* Biöte, were introduced from Java (Phillips, 1941). All these were successfully bred in the laboratory on *A. cocophaga* and certain other local Pentatomid and Coreid bugs and released in large numbers in the coconut plantations on Malaita and Guadalcanal. The results of these liberations are not known.

A. cocophaga is kept under some check by a predacious ant, *Oecophylla smaragdina subnitida* Emery. But in coconut-groves under clean culture the predacious ant was eliminated by another ant, *Pheidole megacephala* (F.). Therefore, in order to improve the biological control of *A. cocophaga* O'Connor recommended a cover-crop with tangled growth in coconut-groves to help *Oecophylla* escape predation by *Pheidole* (O'Connor, 1954; DeBach, 1964).

(18) **Rhinoceros beetle**—*Oryctes rhinoceros* (L.) (Col., Scarabaeidae)

O. rhinoceros has long been a serious pest of coconut in many areas including Ceylon, India, Fiji and many other South Pacific Islands, Indonesia, Malaysia and New Guinea. Attempts at biological control have been made in different areas.

Parasites and predators

INDIA AND PAKISTAN

The Reduviid predator *Platymeris laevicollis* Dist. (but initially considered by the Commonwealth Institute of Entomology, London, to be *Platymerus rhadamanthus* Gerst.) originating in Zanzibar has been introduced into India for trial and 130 adults (80 females) and 200 nymphs were liberated in 1968 on Androth Island in the Laccadives. Additional material for this liberation was also obtained from stocks maintained in Malaysia and Western Samoa and also from the CIBC Pakistan Station (Manjunath *et al.*, 1969). In June 1969, 24 adults (19 mated females) and 4 last instar nymphs were liberated at Oorkere, 4 miles beyond Tumkur (Mysore State). A preliminary report indicates that *Platymeris* is established on Androth Island.

Some 450 adults and nymphs of this predator were released by the CIBC Pakistan Station in the Multan and Bannu areas of West Pakistan and also in East Pakistan but the species has not been recovered.

MALAYSIA

Scolia ruficornis F. (Hym., Scoliidae) introduced from East Africa is being established in various parts of West Malaysia. The predator *P. laevicollis* was also imported from Africa but no release was made since it was feared that it may attack the climbers on coconut trees (Wood, 1964).

In Sabah (East Malaysia) the rhinoceros beetle is a common pest of coconuts, but severe damage occurs only in a few localities which are close to saw mills and town areas where decaying coconut trunks and stumps of wild palms abound. It may, however, become a serious pest of oil palms planted near coconut holdings. In 1961 two species of predacious beetles, *Hololepta quadridentata* (F.) and *Pyrophorus* sp., were imported from Trinidad through the CIBC West Indian Station. Six hundred adults of the former species and 500 of the latter were released in the Tawau area. They have not been recovered to date.

SOUTH PACIFIC TERRITORIES

Since it was known that *Scolia oryctophaga* Coq. from Madagascar was able to breed on *O. rhinoceros* in Java, collections were sent to Samoa in 1939 from Madagascar and Mauritius. Of the 412 female wasps despatched 210 arrived in good condition and were liberated in the field but the species failed to become established, possibly because of the absence of a definite cool season which controls the development of the pupae (Simmonds, 1940 *a*, 1941, 1949; Hoyt, 1957). A small number (14 females) of *S. oryctophaga* was introduced into Fiji from Madagascar and liberated in 1956 at Bau Landing (Coconut Pests and Diseases Board, Fiji, 1956–57). These were sent by Dr. T. V. Venkatraman, one of the team of workers employed by the South Pacific Commission (O'Connor, 1956). In 1954 over 750 adults (almost all females) and in 1959 another 15 males and 39 females obtained from Mauritius were liberated. There is as yet no evidence of its establishment (O'Connor, 1960 *b*).

S. ruficornis which is known to parasitise the grubs of *Oryctes monoceros* Ol. and *O. boas* F. in Zanzibar and on the coast of East Africa was introduced into Western Samoa against *O. rhinoceros* in 1945. A consignment of 465 females was obtained from Zanzibar. A single adult was recovered six months after liberation in Western Samoa. Some 20–30 adults were found hovering over a compost heap in 1949 indicating that the parasite had become established (Simmonds, 1949), and by 1956 it was found to be widely distributed and to have greatly increased in numbers (Coconut Pests and Diseases Board, *loc. cit.*).

Bryan (1949) mentions liberations of *S. ruficornis* from Zanzibar and *Scolia patricialis* Burm. var. *plebeja* Grib. from Malaya in the Palau Islands in 1948. There is no indication that the latter species is established in the Palaus (Gardner, 1958). *S. ruficornis* was introduced into Fiji from the Palau Islands in 1958. The parasite was successfully reared and several colonies were released in a number of localities (Simmonds, 1961). *S. ruficornis* is now established in these islands (Hoyt and Catley, 1967).

Gressitt (1953) reported the introduction of *Scolia procer* Ill. from Malaya into the Palau Islands but that it was not recovered. Introduction was again made in 1963 (FAO Technical Working Party on Coconut Production, Protection and Processing, 1966).

Scolia quadripustulata F. var. *barmanica* Magr. (which was once reared from a second instar grub of *O. rhinoceros* at Amingaon (Assam, India) and *Scolia* (*Campsomeris*) *azurea* Chr. (found hovering over manure heaps at Amingaon) were liberated in Fiji in 1962, but were not established (FAO Technical Working Party on Coconut Production, Protection and Processing, 1966).

The value of *S. ruficornis* in controlling *O. rhinoceros* has been assessed in Western Samoa where the parasite has been established for 20 years. On the island of Upolu the wasp exerts some control of *Oryctes* larvae in compost and sawdust heaps. There is, however, no evidence that the wasps enter into the firmer parts of decaying logs where *Oryctes* breeding mostly occurs, and hence as long as log-breeding sites are abundant, *S. ruficornis* will be of little control value. On the island of Viti Levu in Fiji breeding sites of *Oryctes* in sawdust and artificial compost pits have been provided to sustain the *Scolia* populations because of its discontinuous pattern of distribution, but this may actually worsen the pest situation (Hoyt and Catley, 1967).

Catascopus fascialis Wied. (Col., Carabidae) is known to attack young *Oryctes* grubs in Malaya and a consignment of this Carabid was successfully shipped to Samoa in 1939 (Lever, 1939 *b*); 122 beetles arrived in good condition (Simmonds, 1941). The Histerids *Pachylister eninensis* (Quens.) from Western Samoa in 1952 and *Placodes ebeninus* Lewis from Tanganyika were introduced into the Palau Islands for trial against *O. rhinoceros* (Gressitt, 1953). There is no evidence of establishment of these predators (Gardner, 1958).

Hololepta marginipunctata Mars. (= *Leionota colombiana* Mars.), *H. quadridentata* and probably a third Histerid species of the same genus and the Elaterid *Pyrophorus pellucens* Eschscholtz were introduced into Fiji from Trinidad in 1953. About 4,850 of *Hololepta* spp. were liberated. In 1954, 2,300 more of *Hololepta* spp. were liberated and in 1955 large numbers of the same were received from CIBC and about 9,200 liberated. Thus in the period 1953–55 about 16,500 adults were liberated in the southeast corner of Viti Levu but they have not been recovered since (O'Connor, 1953, 1960 *b*). All these were released near the Tamavua river, where *Oryctes* infestation was reported to be heaviest, and some of the Histerids also near Nausori. *P. chinensis* already occurs in Fiji, having been introduced from Malaya (O'Connor, 1953). Sixty adults of the predacious Carabid *Mecodema spinifer* Broun obtained from New Zealand were also liberated in Fiji (O'Connor, 1955). Another Carabid, *Scarites madagascariensis* Dej., regarded as an efficient predator of Dynastid larvae in Madagascar, was introduced into Fiji against *O. rhinoceros* in 1957. A total of 265 adults were released but since large numbers of toads were later found at the liberation sites it was doubtful whether any Carabid survived (Coconut Pests and Diseases Board, Fiji, 1957–59; O'Connor, 1960 *b*).

Hoyt (1963) considered the Carabid *Neochryopus savagei* Hope as the most important biocontrol agent of *Oryctes* spp. in Nigeria and introduced it into Fiji and Samoa. Another Carabid, *Ochryopus gigas* Schiodte, was also sent (only 14 adults) from Nigeria to Fiji in 1960 (Coconut Pests and Diseases Board, Fiji, 1959–65). No establishment was initially reported (O'Connor, 1964) but a single specimen of *N. savagei* was found in 1969 seven miles from Koronivia (Jona Ulvinaceva, pers. com.). Unsuccessful attempts were also made in Fiji to breed a species of *Scolia* (not in British Museum) received in 1960 from West Africa (Hoyt, 1963).

The Elaterids *Lanelater* (*Agrypnus*) *fuscipes* (F.) and *Alaus speciosus* (L.) were introduced from Ceylon into Western Samoa in 1955 (Cumber, 1957). Both species were recovered in 1965, about a mile from the release sites. Establishment followed the release of only 6 adults, 1 pupa and 38 larvae of *Alaus* and 16 adults and 31 larvae of *Lanelater* (Hoyt and Catley, 1967). *A. speciosus* is being found frequently in association with *Oryctes* larvae in compost and in dead coconut palm trunks (A. Catley, pers. com.).

Since 1961, *Platymerus rhadamanthus* Gerst. (= *Platymeris laevicollis* Dist.) reported by Vanderplank (1958) as a predator of *O. boas* and *O. monoceros* adults in Zanzibar, has been liberated in Fiji, Wallis Island, New Britain, Tonga, Palau Islands and American and Western Samoas (Hoyt and Catley, 1967). This Reduviid is now believed to be established on the island of Upolu in Samoa. Liberations will continue in Tonga and the Tokelau Islands (A. Catley, pers. com.).

The Carabid *Pheropsophus hilaris sobrinus* (Dej.) which feeds voraciously on young larvae of *O. rhinoceros* in manure heaps at Gauhati (Assam, India) was sent to Fiji in 1962 by the CIBC Indian Station (Rao and Manjunath, 1964). Other predators shipped from India into the South Pacific areas in 1962 include the Carabids *Scarites dubiosus* Andr., other species of Scaritids and *Oxylobus punctatosulcatus* Chaud. None of these predators has become established (FAO Technical Working Party on Coconut Production, Protection and Processing, 1966).

Nematodes

During 1957–58 two endoparasitic nematodes, *Rhabditis* sp. nr. *maupasi* Caull. (Rhabditidae) from Ceylon and *Rhabditis* sp. from Madagascar, were introduced into Fiji. These nematodes can kill the larvae and adults of *Oryctes* and other Lamellicorn beetles. They were bred in the laboratory in Fiji and distributed to other territories for trial (Coconut Pests and Diseases Board, Fiji, 1955–1959). On one occasion they were recovered in the field in

Fiji (FAO Technical Working Party on Coconut Production, Protection and Processing, 1966). The effect of these nematodes on *Oryctes* populations is still unknown (O'Connor, 1964).

Certain nematodes found in the *bursa copulatrix* of female *Oryctes* spp. (excluding *O. rhinoceros*) are being investigated in the South Pacific territories. Cross-mating between *O. monoceros* (male) and *O. rhinoceros* (female) has successfully transferred the nematodes to the latter host, but subsequent transmission to male *O. rhinoceros* during copulation has not been demonstrated (A. Catley, pers. com.).

Mites

Hypoaspis (= *Coleolaelaps*) sp., a predator of eggs and newly hatched larvae of *O. monoceros* in the Ivory Coast, West Africa, proved to be an effective predator of newly hatched larvae of *O. rhinoceros* in laboratory experiments in Samoa. This will be liberated for field evaluation in Western Samoa and the Tokelau Islands (A. Catley, pers. com.).

Diseases

In Samoa, Friedrichs (1913, 1920) killed larvae of *O. rhinoceros* by infecting them with the fungus *Metarrhizium anisopliae* (Metsch.) Sorokin. Heaps of decomposing vegetation near a coconut garden were treated with the fungus. Grubs hatching from the eggs laid on these heaps succumbed to the fungus which, however, is very polyphagous and widespread in the wet tropics. The fungus is receiving a final evaluation under field conditions in the South Pacific area (A. Catley, pers. com.).

In 1914 Friedrichs brought *M. anisopliae* collected in various places to Ceylon. Experiments with this fungus in Ceylon showed that it only attacked *Oryctes* larvae which had been held in captivity until their vitality was impaired. Its use was, therefore, not advised (Bryce, 1915, 1923). However, Lester-Smith (1936) found this fungus useful and suggested the laying of traps wherein the fungus could be mixed. The Department of Agriculture, Ceylon, also advocated the use of *Metarrhizium* as a control measure (Leaflet No. 92, 1936). Field evaluation of the fungus has recently been undertaken by the Coconut Research Station in Ceylon (U.B.M. Ekanayake, pers. com.).

A culture of *M. anisopliae* was obtained for use in India from Ceylon in 1937. A number of laboratory and field observations were made (Administrative Reports of the Madras Agricultural Department, 1938–40; Cherian and Ananthanarayanan, 1939; Nirula, 1957; Nirula *et al.*, 1952, 1955; Radha *et al.*, 1956), but to date the possibilities of obtaining practical control in the field have not been encouraging.

A new type of insect virus, *Rhabdionvirus oryctes* Huger, devoid of inclusion bodies, and which was first discovered in Malaya in 1963 by Huger (1966), is being evaluated in laboratory and field experiments in Western Samoa. The virus was introduced into the field in Western Samoa in early 1967. It is now well established practically all over W. Samoa and appears to exercise some degree of control (Semi-Annual Rep., Nov. 1968–May 1969, UNDP (SF) SPC Project on *Oryctes*).

(19) **Coconut leaf-miners**—*Promecotheca coeruleipennis* Blanchard and *P. opacicollis* Gestro (Col., Hispidae)

FIJI

P. coeruleipennis is an indigenous pest of coconut palms, causing sporadic and often extremely severe outbreaks. This species has long been referred to as *P. reichei* Baly. Whilst local parasites originally gave good control under the normal conditions of completely overlapping generations, this situation was upset by the appearance, presumably by accidental introduction, of the mite *Pyemotes ventricosus* Newp., which was first recorded in Fiji in 1921 on *Levuana iridescens*. This attacked *P. coeruleipennis* larvae in such a way that the pest population was reduced to a "one-stage" condition and the native parasites were ill-adapted to cope with this new situation. In 1929 a campaign for biological control was started. *Pediobius* (= *Pleurotropis*) *parvulus* (Ferriere) (Hym., Eulophidae), a parasite of *Promecotheca cumingi* Baly (previously referred to as *P. nuciferae* Maulik) in Java, appeared to be the best suited to meet the requirements in Fiji and was introduced in 1933, when 1,200 individuals were received. Along with these, 378 adults of *Dimmockia javanica* Ferriere, another effective Eulophid larval parasite in Java, were also received. Before liberation of *P. parvulus*, infested areas were thoroughly surveyed to find severe outbreaks, with a view to providing optimum conditions for its establishment. It readily attacked *P. coeruleipennis*. Continuous breeding and release of *P. parvulus* were undertaken for 6 months, after which the parasite had multiplied prolifically in the field, making further release unnecessary. In all, 25,900 individuals were liberated in 48 colonies. The parasite became well established and often accounted for 100% parasitism in severe outbreak areas, virtually annihilating the pest and thereby endangering its own survival in some areas. By May 1934 complete control of *P. coeruleipennis* was obtained in the Lau Islands. *Dimmockia* was also reared and liberated in considerable numbers but it failed to become established (Taylor, 1937).

Pediobius (= *Pleurotropis*) *painei* (Ferriere) was also introduced from Java. Only 14 adults (11 females and 3 males) received alive were liberated in the field and it was not established.

NEW HEBRIDES

P. opacicollis, a serious pest of coconuts in the New Hebrides, was completely controlled by *Pediobius parvulus* introduced from Java in 1937 (Lever, 1938 *b* and Cohic, 1953).

(20) **Coconut leaf-Hispids**—*Brontispa* spp.

Different species of *Brontispa* occur in Malaysia, the Philippines, the British Solomon Islands and Indonesia. There are a number of indigenous parasites in these areas.

INDONESIA

In 1932 and 1933 *Tetrastichus* (*Tetrastichodes*) *brontispae* (Ferriere) (Hym., Eulophidae) was introduced from West Java into South Sulawesi (Celebes), where it successfully controlled heavy outbreaks of *B. longissima* (Gestro) var. *selebensis* Gestro. It was recovered in 1933 in several places and a maximum of 90% parasitism of *B. l. selebensis* was recorded. Further importations and liberations reduced the pest to an insignificant level (Awibowo, 1934).

However, attempts to rear and establish this parasite against *B. l.* var. *javana* Weise in East Java between 1932 and 1937 and in Central Java during 1954 proved unsuccessful. Tjoa Tjien-Mo (1965) found that *B. l.* var. *javana* occurs in two strains, one of which is resistant and the other susceptible to parasitism by *T. brontispae*. This was considered responsible for the failure of the parasite to become established in these areas.

MARIANA ISLANDS

T. brontispae and *Haeckeliana brontispae* Ferriere (Hym., Trichogrammatidae) obtained from Malaya and Java in 1948 were released against *Brontispa mariana* Spaeth on Saipan and Rota. *T.brontispae* became well-established on both islands, with larval and pupal parasitism reaching 89% in some locations. On Saipan the beetle was well-controlled by the parasite when observations were made in 1954. *H. brontispae* failed to become established (Bryan, 1949; Doutt, 1950; Lange, 1950 and Gardner, 1958).

SOLOMON ISLANDS

T. brontispae was introduced into the Solomon Islands from Java. In 1936 about 40,000 parasites were released in a block of ten-year old palms on Banika Island in the Russell group (Lever, 1937). Following continued liberations it was reported to have become successfully established (Johns, 1941). However, according to O'Connor (1940 *b*), no significant results have been achieved by its introduction.

(21) **Coconut caterpillar**—*Nephantis serinopa* Meyrick (Lep., Xyloryctidae)

Conservation of indigenous parasites and introduction of exotic parasites of this serious defoliator have been attempted in Ceylon and India.

CEYLON

Elasmus nephantidis Rohw. (Hym., Elasmidae), *Bracon brevicornis* (Wesm.) (Hym., Braconidae) and *Tetrastichus israeli* Mani and Kurian (Hym., Eulophidae) obtained from the CIBC Indian Station were mass-bred at Batticaloa and Lunuwila and liberated during 1961–63 (Dharmaraju, 1963). Though very large numbers of *B. brevicornis* were released, it failed to become established (U. B. M. Ekanayake, pers. com.). In addition, two Hawaiian species (*Brachymeria obscurata* and *Echthromorpha agrestoria fuscator* (F.) (Hym., Ichneumonidae) were also sent to Ceylon by the CIBC Indian Station but neither species proved useful in controlling the pest.

The indigenous parasites *Perisierola nephantidis* Mues. (Hym., Bethylidae), *Spoggosia* (*Stomatomyia*) *bezziana* (Bar.) (Dip., Tachinidae) and *Trichospilus pupivora* Ferr. (Hym. Eulophidae) were also mass-bred and released. *T. pupivora* has been released for several years. In the North-Western Province where the climate is cooler than in the east coast of Ceylon, *Trichospilus* remains the dominant factor in the control of the pest (Backhouse, 1939; Dharmaraju, 1963; Jayaratnam, 1941; Dep. Agric., Ceylon, Adm. Repts. 1936–38, 1940, 1947–50, 1954, 1955, 1957, 1958). In the Eastern Province where *T. pupivora* also parasitised the puparia of *S. bezziana*, the efficiency of this Tachinid was seriously impaired (Dharmaraju, 1963). Assessment of the degree of control of *N. serinopa* exerted by parasites is still being attempted, but is proving difficult for lack of suitable methods of assessment (U. B. M. Ekanayake, pers. com.).

INDIA

An extensive survey indicated a diversified parasite and predator complex attacking *N. serinopa* (Dharmaraju, 1962). Since that on the east coast differs considerably from that on the west, it was thought advisable to try introducing parasites from one area into the other. *Apanteles taragamae* Vier. (Hym., Braconidae), *B. brevicornis*, *P. nephantidis* and *T. pupivora* were bred and released in areas where they were not present. *A. taragamae* was introduced into the Mangalore area from the east coast in 1924–25 and subsequently into the Ponnani and other South Malabar areas in 1926–28. Though it became established its control value was reduced by hyperparasites. Several attempts to introduce *B. brevicornis* into North Malabar were unsuccessful (Ramachandra Rao *et al.*, 1948). However, in Andhra Pradesh where it was continuously released, it did well along the coastal belt. *P. nephantidis* was mass-bred and released in Andhra Pradesh and was reported as doing excellent work (Dharmaraju, 1952). Liberations of *T. pupivora* made in Mangalore in 1924 were unsuccessful. Another attempt in 1925 gave some success (Jayaratnam, 1941). *Trichogramma minutum* Riley (see footnote on page 22), an egg-parasite of sugarcane borers, was also found to attack the eggs of *N. serinopa*. A total of some 4,900,000 parasites were released for trial against fresh infestations of the pest (Adm. Rep. Dept. Agric., Madras, 1950–51). Large-scale liberations of *T. pupivora* in Kerala brought about control of the pest for a limited period (Nirula, 1956). There is a general belief in India that conservation of the indigenous parasites has helped in controlling *N. serinopa* to some extent though no quantitative assessment of the control thus achieved has been made. Nevertheless, the pest continues to cause heavy damage to coconut palms in many areas. The Tachinid *S. bezziana* was obtained from the Eastern Province of Ceylon by the CIBC Indian Station. It was bred and released at Coimbatore and Gudiyatham (Tamil Nadu) and Puri (Orissa) during 1962–1964. Recoveries were made subsequently in small numbers at Coimbatore and Gudiyatham. Even though this parasite is likely to become permanently established in India, its value in the presence of the hyperparasitic *T. pupivora* is uncertain.

In 1963 *S. bezziana* was recovered from larvae of *Pelopidas mathias* (F.), a minor pest of paddy, at Sirpur (Orissa) (Rao *et al.*, 1969). A culture of this Tachinid was maintained at Sirpur but no releases were made. Possibly the parasite had escaped from the laboratory or while being transported to Puri for field-release, and attacked *Pelopidas*.

(22) **Coconut leaf-moth**—*Artona catoxantha* Hmps. (Lep., Zygaenidae)

MALAYSIA

According to Tempany (1935) the Tachinid parasite *Ptychomyia remota* was sent to Labuan Island (Sabah, East Malaysia) from Malaya in 1934 to control *A. catoxantha* and coconut leaves received from Labuan later in the year showed empty puparia of the parasite, indicating that the Tachinid might have become established. However, it is not known whether any prior survey was made on Labuan Island to check whether the parasite was not already present.

PHILIPPINES

In 1957 about 80,000 *T. australicum*, previously introduced from Formosa to control rice stem-borers, were sent to Palawan for field-liberation. Although the species became established in Luzon and Negros nothing is known of its establishment on *Artona* in Palawan (Baltazar, 1963).

(23) **Coconut flat-moth**—*Agonoxena argaula* Meyr. (Lep., Agonoxenidae)

FIJI

A. argaula is a pest of coconut palms in many of the Pacific islands, including Fiji. A biological control programme was started in 1958 and a number of parasites were introduced: *Chelonus* sp. (Hym., Braconidae) and *Elachertus* sp. (Hym., Eulophidae) from Australia, *Elachertus* sp. from New Guinea, *Apanteles stantoni* (Ashm.) (Braconidae) and *Actia painei* Crosskey (Dip., Tachinidae) from New Britain and *Macrocentrus* sp. (Hym., Braconidae) from Java. A total of 115 *Elachertus* and 7 *Apanteles* were liberated in the field (O'Connor, 1960 *a* and *b*). The numbers of the other species released are not known. Subsequently, a survey was conducted and the Javanese parasite *Macrocentrus* sp. was found to have become temporarily established near a release point (Hinckley, 1963 *a*). Later Szent-Ivany (1964) reported that *Macrocentrus* sp. could no longer be found.

(24) **Small leaf-moth of coconut**—*Levuana iridescens* Bethune-Baker (Lep., Zygaenidae)

FIJI

This is a serious pest of coconut, the larvae causing considerable defoliation. A biological control campaign was instituted in 1925 following severe outbreaks of the pest. From an extensive survey it was concluded that the pest was not indigenous to Fiji because of the absence there of any natural enemies. In 1925 the following parasites known to attack a variety of hosts were imported from Hawaii and liberated in the hope that one or two of them might prove useful against the pest: About 100 *Trichogramma pretiosum* Riley (Hym., Trichogrammatidae), 100 *Microbracon* (*Macrodyctium*) *omiodivorum* Terry (Hym., Braconidae), 100 *Brachymeria obscurata* (Hym., Chalcididae), 12 *Echthromorpha agrestoria fuscator* Fb. (= *Ecthromorpha maculipennis* Holmgren) (Hym., Ichneumonidae), 280 *Achaetoneura* (= *Frontina*) *archippivora* Will. (Dip., Tachinidae), 24 *Casinaria infesta* Cress. (Hym., Ichneumonidae) and 12 *Chelonus blackburni* Cam. (Hym., Braconidae). In addition, some 1,000 *Euplectrus platyhypenae* How. (Hym., Eulophidae), a parasite of armyworms (not known specifically) were also introduced. Three months later Tothill recovered *E. platyhypenae* at a point about 8 miles from the liberation site. None of the others was recovered (Tothill *et al.*, 1930).

In 1925 *Ptychomyia remota*, a Tachinid parasite of *Artona catoxantha*, was introduced from Malaya. Only 315 parasites reached Fiji alive (Jack, 1935). These were sucessfully bred on *Levuana*. Altogether 38 colonies, with a total of 32,621 flies, were liberated from August 1925 to February 1926. Only one of these liberated at Nanuku failed because of the scarcity of host larvae resulting from severe defoliation of the palms. *Ptychomyia* spread very quickly, and in the Nasese District parasitism was 50 to 100% within a matter of months after liberation. In the Suva District parasitism increased so rapidly that within three months after liberation the pest was completely exterminated.

Six months after its first introduction *Ptychomyia* was found throughout the *Levuana*-affected parts of Fiji, and there was no report of any new outbreaks of *Levuana* from any part of Fiji for three years. Such a rapid spread may be attributed to the strong flying power of the adult parasites and also to the large numbers and overlapping broods of *Levuana*, as well as to the absence of secondary parasites.

As a result of this remarkable and spectacular success in the biological control of *L. iridescens*, planting of coconuts in hitherto non-productive areas of Fiji was resumed.

Callimerus arcufer Chapin (Col., Cleridae), a predator of *A. catoxantha* in Malaya, was also introduced in 1925. 1,109 individuals were liberated in 21 colonies but no recoveries were made (Tothill *et al.*, 1930).

Several species of insectivorous birds were introduced from Ceylon and India and their behaviour was studied in the laboratory. A series of experiments demonstrated that none of the birds would eat *Levuana*. For this and other reasons the birds were not released (Tothill *et al.*, 1930).

(25) **Coconut spike-moth**—*Tirathaba complexa* Btlr. [= *T.* (*Coleoneura*) *trichogramma* Meyr.] (Lep., Pyralidae)

T. complexa larvae feed on flowers of coconut in Fiji (O'Connor, 1950 *b*) and a *Tirathaba* sp. causing similar damage has been reported from India (Fletcher, 1920). In Fiji, the loss of female flowers was estimated to reduce copra production by over 30 per cent (O'Connor, 1950 *b*).

FIJI

Five species of parasites were introduced from Java. In 1930 the Braconid *Apanteles tirathabae* Wlkn. was introduced from Java, where it parasitised the allied *Tirathaba rufivena* Wlk. and *T. mundella* Wlk. (Taylor, 1930). Large numbers were bred on *T. complexa* in the laboratory and liberated in the field. It became established rapidly and in 1931 gave 62% parasitism in and around Suva (Viti Levu) but was less effective on the island of Taveuni. *Telenomus tirathabae* Ferriere (Scelionidae) was introduced in 1931, when some 30,000 adults were liberated. It was recovered in one locality 5 months after liberation. By 1934 nearly 80,000 *T. tirathabae* and 26,000 *A. tirathabae* had been liberated in 52 islands of Fiji. Both species were established in 4 islands. Parasitism by the former averaged 32% in four localities and that by the latter species ranged from 0 to 33% in various localities (Paine, 1935).

Devorgilla (*Nemeritis*) *palmaris* (Wlkn.) (Hym., Ichneumonidae) was introduced in 1933 when over 11,000 individuals were liberated on Taveuni and 15 other islands, and recoveries were subsequently made from two. It spread and gave a higher parasitism (32%) in Fiji than in Java.

Argyrophylax (*Erycia*) *basifulva* (Bezzi) was introduced in 1931 when a few colonies were liberated on Taveuni and Vanualevu, but was not recovered. In 1933 it was re-introduced with further material from Java along with more *D. palmaris* and *Palexorista painei* (Baranov) (= *Sturmia painei* Baranov). A total of 45,000 were liberated in 10 islands. *Argyrophylax* was recovered from 4 islands. Of all the parasites introduced into Fiji from Java, this Tachinid exercised the maximum control. *P. painei* could not be bred in Fiji as few adults survived the journey (Paine and Surridge, 1932; Lever, 1945 *a*; Paine, 1935).

(26) **Mealybugs**—*Ferrisia virgata* (Ckll.) and *Rastrococcus iceryoides* (Green) (Hem., Coccidae)

INDONESIA

The Coccinellid predator *Cryptolaemus montrouzieri* (Muls.) imported into Java from Hawaii (origin Australia) in 1918 by Van der Goot to control *F. virgata* became established throughout eastern Java but its practical value seems not to have been ascertained (Gandrup, 1925).

Another mealybug, *R. iceryoides*, was a severe pest of coffee in southern Celebes, and according to Van der Goot (1948 *b*) it infested about 50,000 coffee plants in the Toradja district in 1926. *C. montrouzieri* was introduced into southern Celebes from Java in 1928 and successfully controlled the pest. From a review of the work on the use of *C. montrouzieri* in Indonesia it is concluded that this Coccinellid will prove successful only against mealybugs that are not attended by ants, or are attended only sporadically, and are present in sufficient numbers throughout the year (Van der Goot, 1948 *b*).

(27) **Coffee berry-borer**—*Hypothenemus* (*Stephanoderes*) *hampei* (Ferr.) (Col., Scolytidae)

CEYLON

A shipment of the Braconid *Heterospilus coffeicola* Schmied. and the Bethylid *Prorops nasuta* Wtstn. was received from Uganda in 1938. Soon after arrival about 220 *Prorops* and a few *Heterospilus* were liberated in a small area of coffee heavily infested by the berry-borer. Later 530 *Prorops* bred in the laboratory were released in the same area. Neither of these parasite species became established (Hutson, 1939 *b*).

INDONESIA

From Uganda *H. coffeicola* and *P. nasuta* were shipped to Java for use against *H.* (*S.*) *hampei* in 1923 (Friedrichs, 1925) and were bred at Malang. *P. nasuta* was tested in the laboratory and liberated in the field but it was not successful in controlling the pest although it became established, at least temporarily (Kalshoven, 1950).

(28) **White stem-borer**—*Xylotrechus quadripes* Chevr. (Col., Cerambycidae)

INDO-CHINA

Attempts were made to breed the local Braconid parasite *Doryctes strioliger* Kieff. and the Bethylid *Sclerodermus domesticus* Kieff., and release them against the coffee-borer. From 1920 to 1924 about 3,800,000 *D. strioliger* were bred and distributed in various coffee estates. However, these did not bring about any reduction in the losses due to the borer. Several thousand *S. domesticus* were bred and distributed. The Evaniid *Pristaulacus nigripes* Kieff. was reared from the borer in North Annam and liberated on the Cho-Ganh plantation where it was absent (Duport, 1924, 1925). These efforts do not appear to have resulted in any significant control.

Cotton

(29) **Cotton boll-worms**—*Earias* spp. (Lep., Noctuidae) and *Platyedra gossypiella* Saund. (Lep., Gelechiidae)

INDIA AND PAKISTAN

Of over 100 species of insects and mites attacking cotton in India the most destructive are the spotted boll-worms *Earias insulana* Boisd. and *E. fabia* Stoll. and the pink boll-worm *P. gossypiella*. Many species of parasites have been recorded from these hosts, and some fundamental work has been done in the laboratory on the biology of a few. So far attempts in India to control boll-worms biologically have been by using indigenous natural enemies (Khan and Rao, 1960; Narayanan, 1960). These have only been successful for limited periods, if at all. Attempts to import exotic parasites of boll-worms have never been pursued adequately for lack of funds. Attempts to encourage and distribute the indigenous parasite *Bracon greeni* (Ashm.) at several places in the former undivided Punjab are reported to have given satisfactory results against *Earias* (Madan Mohan Lal, 1913; Chopra, 1928). However trials with this parasite against the spotted boll-worms in Gujarat in the early twenties were only successful to a limited extent (Deshpande and Nadkarny, 1936).

Several trials have been carried out with what was called *Trichogramma minutum**. This species was bred in the laboratory on the eggs of *Corcyra cephalonica* St. and released regularly against *E. fabia* and *P. gossypiella* on cotton at Coimbatore in Tamil Nadu (former Madras State). In an experiment 18 liberations were made in four half-acre plots from mid-December 1941 to the end of February 1942 at the rate of 5,000 parasites per plot every four days Opened bolls from the treated and control plots were examined for boll-worm incidence. Some reduction in boll-worm incidence was noticeable (Cherian and Margabandhu, 1943). For a second year in succession parasite liberations were continued and in all 18 liberations were made in two fields at intervals of 4 days, from the end of December 1942 to mid-March 1943, at the rate of 10,000 parasites per liberation per acre. Subsequent examination showed that the boll-worm infestation was nearly four times higher in the uncolonised fields than in the colonised fields. Parasite releases were continued in 1943–44 and 21 liberations made. These resulted in reduced incidence of boll-worms (Adm. Reps., Govt. Entomologist, Madras, for 1942–43 and 1943–44).

Four plots of Cambodia cotton situated at fairly long distances from each other at the Central Farm, Coimbatore, were selected and 10,000 parasites per acre per week were liberated in two plots from November 1948 to February 1949. The results were assessed by periodical examination of the buds during the flushing season and of the bolls during the later stages. Infestation of bolls by *Platyedra* came down progressively from 68% in February to 41% in March, whereas in the controls it remained more or less at 75%. The colonised plots gave an yield of 1,158 lb. cotton per acre while the controls gave 1,033 lb. Though the increase in the yield may not be striking the quality of the produce was found to be uniformly superior. In another experiment, weekly releases were made at the rate of 20,000 *Trichogramma* adults in a two-acre field. Infestation went up to 58·4% in the control but only up to 15% in the colonised plot (Adm. Reps., Govt. Entomologist, Madras, for 1948–49 and 1951–52).

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* It seems most unlikely that *T. minutum* occurs in India or possibly even in Asia. The species reported by various authors as *minutum* and used for the biological control of sugarcane borers and cotton boll-worms by mass multiplication and liberation is in fact *T. australicum* Gir. (Nagarkatti & Nagaraja, 1968.)

Some attempts were made in 1958–59 to use the indigenous Braconids *Apanteles angalet* Muesebeck and *Bracon brevicornis* to control the pink boll-worm at Karnal (Punjab) (Narayanan, 1960) but apparently these have not been followed up.

PHILIPPINES

Trichogramma minutum introduced from the U.S.A. in 1934 for trial against lepidopterous pests has been recovered from *P. gossypiella* and *E. fabia* (Baltazar, 1963).

(30) **Cotton leaf-roller**—*Sylepta derogata* (F.) (Lep., Pyralidae)

PAKISTAN

In 1960 CIBC Pakistan Station obtained *Trichospilus pupivora* from India and *Horogenes* sp. (Ichneumonidae) and *Microgaster subcompleta* Nees (Braconidae) attacking *Sylepta ruralis* Scop. from Switzerland through the CIBC Stations in these countries. *T. pupivora* was successfully bred in the laboratory and liberated in the fields against *S. derogata* but did not become established. The other two species failed to breed on *S. derogata* in the laboratory.

Maize and Sorghum

(31) **Stem-borer**—*Chilo partellus* (Swinh.) [= *zonellus* (Swinh.)] (Lep., Pyralidae)

INDIA AND PAKISTAN

Attempts have been made in India to control the sorghum stem-borer *C. partellus* by periodic releases of the native egg parasite *Trichogramma* and larval parasite *Bracon brevicornis*.

Trichogramma evanescens minutum Riley (see footnote on page 22) was mass-bred and released in Mysore and Bellary districts of Mysore State. Parasitism went up initially but this was not maintained later (Puttarudriah and Usman, 1957; Usman *et al*., 1964). Weekly releases of *Trichogramma* at the rate of 20,000 adults per acre were made in two one-acre non-irrigated blocks at Coimbatore (Tamil Nadu). As a result the infestation in the colonised blocks ranged from 8·5% to 31·5% as against 9% to 41% in the controls. Similarly 7 weekly liberations were made in the irrigated blocks. Infestation ranged from 3% to 20·5% in colonised and from 8·6% to 47% in the control plots (Adm. Rep., Govt. Entomologist, Madras, for 1950–51). *T. minutum* and *B. brevicornis* were released at Karnal (Punjab). During 1957 parasitism by *Trichogramma* rose to 93·1% and in 1958 to 85·1% in the colonised plots as compared with 38% and 29% respectively, in plots where no parasites were liberated (Katiyar, 1962). Results of the release of *B. brevicornis* are not known.

At Lyallpur, *T. minutum* was released four or five times a week during August-September in 1944–46 at the rate of 8,000 adults per liberation in two one-acre blocks of maize. There was 17% to 28% increase in the grain yield in the colonised fields. The experiments were repeated in 1948-50 but with rather conflicting results.

Recently *Apanteles chilonis* (Munakata) and *A. sesamiae* Cam. obtained from Japan and East Africa, respectively, by the CIBC Indian Station were mass-bred and released at Mandya

(Mysore State), Plassey (West Bengal) and Nellikuppam (Tamil Nadu). The parasites have not as yet been recovered. Cultures sent to the Punjab Agricultural University, Ludhiana, and to the State Entomologist, Kashmir, could not be maintained there. An *Apanteles* sp. was introduced into Pakistan from Japan by the CIBC Pakistan Station. A total of over 76,000 adults were released in Lahore, Rawalpindi and Rawalkot (Kashmir) areas. "*A. flavipes*" was known to occur in Pakistan but only on *Sesamia inferens* in *Typha angustata* (Bory & Chaub.). A major survey undertaken prior to these releases had shown that of about 29,000 *C. partellus* including 16,000 examined by Carl (1962) not a single one was parasitised by the local *Apanteles*. After the releases *Apanteles* sp. became common on *C. partellus* and was found up to 170 miles from the release sites. At certain spots parasitism built up to 81%. *A. chilonis* was obtained from Japan in 1966. Some 17,000 adults were released in the D. G. Khan, Rawalpindi and Murree areas of West Pakistan. It was recovered from Rawalpindi, where parasitism at the release sites built up to 60% but declined as soon as winter approached. It was not recovered from hibernating larvae during winter.

Pediobius furvus (Gah.) (Eulophidae), a pupal parasite, was obtained from the CIBC East African Station in 1968. 1,800 adults were released at Rawalpindi and the species was recovered once from a single pupa.

(32) **Corn-borer**—*Ostrinia furnacalis* (Guen.) (Lep., Pyralidae)

As a result of a recent taxonomic study of *Ostrinia* spp. by Mutuura and Munroe (1970) previous records of the European corn-borer *O. nubilalis* (Hb.) from Guam, Indonesia and the Philippines appear to be erroneous and the corn-borer occurring here is actually *O. furnacalis*.

GUAM

Exeristes roborator (F.) (Hym., Ichneumonidae) introduced from the U.S.A. in 1928 having failed to control this corn-borer, *Lydella stabulans* var. *grisescens* R.-D. (Dip., Tachinidae), *Trathala flavo-orbitalis* and *Eulimneria* sp. (Ichneumonidae) were obtained from Japan and liberated in 1930–31. *Lydella* became established and gave very good control for some years but had almost disappeared by 1951. *Macrocentrus gifuensis* Ashm. (Hym., Braconidae), *Eriborus giganteus* Szép. [= *Angitia* (*Dioctes*) *punctoria* Romen] (Ichneumonidae), *L. s. grisescens* and *Chelonus annulipes* Wesm. (Braconidae) were imported from the U.S.A. and liberated in 1952 and with *Agathis agilis* (Cress.) (Brac.) again in 1954. Several adults of *Lydella* were recovered after the first liberation but none after the second. There is no evidence of establishment of any of these parasites (Vandenberg, 1930, 1931, 1933; Peterson, 1956 *a* and Gardner, 1958).

It may be added that the parasites introduced from the U.S.A., except *Agathis*, are not native to that country but species imported from Europe and other areas for trial against the European corn-borer (Clausen, 1956).

PHILIPPINES

In 1953 shipments of *L. stabulans grisescens*, *M. gifuensis* and *E. giganteus* were received from the U.S.A. A total of 40 adults of *M. gifuensis*, 170 of *L. stabulans grisescens* and 207 of *E. giganteus* were liberated in the corn-fields. None became established (Baltazar, 1963).

Potato

(33) **Potato tuber-moth**—*Phthorimaea operculella* (Zeller) (Lep., Gelechiidae)

INDIA

Bracon (*Microbracon*) *gelechiae* (Ashm.) was imported from Canada in 1944 and bred in large numbers using *Corcyra cephalonica* as laboratory host at the Indian Agricultural Research Institute, New Delhi (Isaac, 1946). It was primarily intended for introduction in potato storage godowns since the occurrence of the pest in the field was not sufficiently known at that time Several attempts to establish this species in godowns in Bihar were made in 1952, 1957 and 1958. The efforts made in 1952 and 1957 failed but the results of the trials made in 1958 in Bihar Shariff, Patna City and Sabour under identical conditions showed that "the parasite can establish itself and be used profitably", as reported by Sen (1964). A nucleus stock of this parasite was received from New Delhi and multiplied on a large scale at Coimbatore and Fernhill (Tamil Nadu). Releases were made in the Nilgiris in the field as well as in godowns. These were not successful (Adm. Rep., Govt. Entomologist, Madras, for 1948–49). However, *B. gelechiae* was reared in large numbers from potato tuber-moth larvae collected at Bangalore and Chickballapur (Rao and Ramachandran Nair, 1967) although Usman (1957) who made a study of the parasites of the pest in Mysore State, did not record it. Parasitism in 1965 and 1966 was 30% and 33%, respectively. Large number of *Trichogramma* (see footnote on page 22) were released in godowns at the Agricultural Research Station, Nanjangud (Mysore State) where seed material harvested by June 1948 from the irrigated crop had been stored for sowing the second crop around September 1948. As a result of the effective work done by the parasites, moths were entirely absent from the godowns. Releases of the parasite were continued on the main-crop seed harvested during December 1948. Here also there were indications of the pest having been kept in check. *Trichogramma* sp. was also released in potato godowns at Coonoor, Ketti (Tamil Nadu) but the results are not known (Adm. Reps. Govt. Entomologist, Madras, for 1947–50).

In 1964 and 1965 seven species of parasitic Hymenoptera were sent from the Californian Station, CIBC, to the Indian Station: the Braconids *Agathis unicolor* (Schr.), *Apanteles scutellaris* Mues., *A. subandinus* Blanch. and *Orgilus lepidus* Muesebeck, the Ichneumonids *Campoplex haywardi* Blanch. and *Temelucha* sp., all larval parasites, and the Encyrtid egg-larval parasite *Copidosoma koehleri* Blanch. (later identified as *Copidosoma uruguayensis* Tach.). *A. scutellaris* is of North American origin while the rest are from South America, which is the centre of origin of the tuber-moth. *Orgilus parcus* Turner and *Diadegma stellenboschense* Cameron (Ichneumonidae) from South Africa and *D. raoi* Gupta (from Cyprus) were also introduced. These were bred and released in Mysore State. The results now available indicate that *O. lepidus*, *A. subandinus*, *A. unicolor* and *C. uruguayensis* appear to have become established at Chickballapur and Hassan (Mysore State) where they were released. A single adult of *D. raoi* was reared during August 1969 from a tuber-moth larva collected at Chickballapur (unpublished reports of CIBC).

Rice

(34) **Rice stem-borers**

Biological control of rice stem-borers has been attempted in Ceylon, Indonesia, Malaysia and the Philippines.

CEYLON

Trichogramma japonicum Ashm., obtained from the Philippines but later also found in India, was sent to Ceylon by the CIBC Indian Station for trial against *Ancylolomia chrysographella* (Koll.) (Lep., Pyralidae) and *Chilo suppressalis* (Wlk.) (Lep., Pyralidae). The parasite was released but has not been recovered (H.E. Fernando, pers. com.).

INDONESIA

During 1954–56 about 5,000 hibernating larvae of *C. suppressalis* were received from Japan. From these larvae, a few thousand adults of *Apanteles chilonis* were reared and liberated in infested rice-fields in Bogor and Krawang. A few *Microgaster russata* Hal. (Hym., Braconidae), *Chelonus munakatae* Mun. (Braconidae), *Temelucha biguttula* Matsumura (= *Cremastus chinensis* Vier.) (Hym., Ichneumonidae) and *Casinaria* sp. (Ichneumonidae) also emerged and some of the *C. munakatae* were liberated in the same locality. In the laboratory, abou one-third of the hibernating *Chilo* larvae developed a fungus infection which was thought to be *Beauveria bassiana* Bals. (Dresner, 1958). The results of these liberations are not known.

MALAYSIA

*Trichogramma minutum** was released in a number of small plots in 1930–31 but was not effective in controlling stem-borers (Corbett, 1932–33).

In 1951 the Tachinid *Paratheresia claripalpis* (Wulp.) was imported from Trinidad to control rice stem-borers. In that year 20 consignments of puparia were received from the CIBC West Indian Station. The parasite was successfully reared in the laboratory on *Chilo polychrysa* (Meyr.) and *C. suppressalis*. The parasite was again imported from Trinidad in 1952 and more than 8,000 adults were released over a period of six months. No recoveries were made subsequently during surveys in 1952, 1953 and 1955.

Metagonistylum minense Tns. (Tachinidae) was also obtained from Trinidad in 1951 but the females usually died within five days in the laboratory (Lever, 1956).

PHILIPPINES

T. japonicum was introduced from Japan in 1934 and again in 1954. It was recovered from the eggs of *C. suppressalis* and *Tryporyza incertulas* Wlk. *Trichogramma australicum* was introduced from Taiwan primarily against rice stem-borers but liberated in the fields infested with rice case-worms, corn-borer, corn-earworm, tobacco-budworm, sugarcane-borers and other lepidopterous pests found on Luzon. Although this species also became established in sugarcane fields it has not been recovered from rice pests (Baltazar, 1963; Cendana and Calora, 1967).

The Tachinid *Sturmiopsis inferens* Tns. has been sent (1966–1969) to the International Rice Research Institute by the CIBC Indian Station for trial against rice stem-borers. A total of 868 adults were released from 1966 to 1969 at selected sites in different localities on Luzon island. The parasite was recovered at most of the release sites 2 to 3 weeks after liberation At two sites it was recovered 30 days after release of mated females. However, sampling done in these sites showed low parasitism. Whether the parasite has become permanently established is uncertain (M. D. Pathak and J. I. Calderon, pers. com.).

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* See footnote on page 22.

M. minense was introduced in 1967 through the CIBC West Indian Station, Trinidad. Low parasitism was observed on *C. suppressalis* and *C. polychrysa* (Anon, 1967).

Other Rice Pests

(35) **Leaf-roller**—*Susumia exigua* (Butler) (Lep., Pyralidae) and *Cnaphalocrocis medinalis* Guenee (Lep., Pyralidae)

FIJI

Until 1961 the rice leaf-roller *S. exigua* in Fiji had been misidentified as *Marasmia venilialis* Wlk.).

Trathala flavo-orbitalis, a parasite of Pyralids, introduced from Hawaii in 1928 and again in 1935, was recorded for the first time from *S. exigua* in 1944 and since then it appears to be a very important factor in the control of this leaf-roller (O'Connor, 1950 *b*, 1954; Hinckley, 1963 *b*).

INDIA

Trichogramma australicum (see footnote on page 22) has been distributed from Coimbatore to parts of Andhra Pradesh and released against *C. medinalis* (Adm. Reps., Govt. Entomologist, Madras, for 1949–50 and 1951–52).

(36) **Swarming caterpillars and cutworms**—*Spodoptera mauritia* (Boisd.), *Mythimna separata* (Wlk.) and *M. loreyi* (Dup.) (Lep., Noctuidae)

FIJI

In 1950 *Apanteles marginiventris* Cress. (Hym., Braconidae) and *Eucelatoria armigera* Coq. (Dip., Tachinidae) were imported from Hawaii against *M. separata*. The former was directly released in the field and also bred on *M. separata* in the insectary. Though attacked by several native secondary parasites, it soon became well-established throughout the island of Viti Levu and prevented serious outbreaks of the pest. Only 30 adults of *E. armigera* were released and the species did not become established. The entire breeding stock was wiped out by a bacterial disease (O'Connor, 1954, 1960 *b*).

In 1956 three shipments containing a total of 400–500 adults of the Tachinid *Achaetoneura archippivora* were received from Hawaii. It was easily bred on *Spodoptera litura*, *S. mauritia* and *Heliothis armigera* (Hb.) and nearly 10,000 flies were liberated over a period of eight months. No recoveries were made (O'Connor, 1960 *b*).

PHILIPPINES

In 1928 *Euplectrus platyhypenae* was obtained from Hawaii and released against *S. mauritia* and *Mythimna* (= *Leucania*) *loreyi*. It is not known whether the parasite became established.

In 1934 the Tachinids *A. archippivora*, *Archytas cirphisae* (Cur.) and *Chaetogaedia monticola* Big. were introduced from Hawaii to control armyworms and cutworms but none has been recovered (Baltazar, 1963).

Sugarcane

Amongst the most serious pests of sugarcane are the lepidopterous borers. These internal feeders are difficult to control even with modern insecticides. Considerable attention has been paid to the biological control of lepidopterous borers in this region. A general survey of the biological control of borers and other pests of sugarcane occurring in various parts of the world has been given by Simmonds (1969 *a*) and more detailed accounts of the investigations on individual species have been published by Metcalfe and Breniere (1969), Bennett (1969), Avasthy (1969), Rao and Nagaraja (1969) and Wilson (1969).

(37) **Sugarcane leaf-hopper**—*Pyrilla perpusilla* Wlk. (Hem., Lophopidae)

NDIA

Indigenous egg-parasites have been used against *P. perpusilla* with some success. In 1935 some 2,900 egg clusters of *Pyrilla* parasitised by *Ooencyrtus papilionis* Ashm. (Hym., Encyrtidae) and *Tetrastichus pyrillae* Crwf. (Hym., Eulophidae) were placed in a 2-acre block of sugarcane in the Punjab. Parasitism increased from 2 to 55% in less than four weeks whereas it was only 2 to 9% in a control block nearby (Rahman, 1941).

In 1938 Muliyil tried conservation of egg-parasites of *Pyrilla* at Meerut (Uttar Pradesh). Subsequently, Vevai conducted a similar experiment at Karnal (Punjab). Egg-masses were placed in wooden cages with wire-gauze sides allowing only the parasites to escape, and these cages were set out regularly in the fields. Percentages of eggs parasitised in the field increased in ten days from 25·7 to 59·8 in the leaf sheaths and from 68·6 to 73·4 on the leaves (Vevai, 1942; Muliyil and Lakshmanan, 1942). Sen (1948) also conducted a similar experiment at Hanumangarh farm in Motipur District and at the Motipur farm in Muzaffarpur (Bihar). A steady rise in parasitism was observed in the treated plots (52% and 35%, respectively in two plots) whereas the 'control' showed an appreciable drop in parasitism.

In 1942 Ahmad reported that the use of the native *Brumus suturalis* F. (Col., Coccinellidae) and *Chrysopa* sp. (Neur., Chrysopidae) at Bhopal for the control of *Pyrilla* gave encouraging results.

(38) **Pink mealybug**—*Saccharicoccus sacchari* (Ckll.) (Hem., Coccidae)

PHILIPPINES

Owing to the increased damage to cane by this mealybug on the island of Negros a Coccinellid, *Scymnus* (*Pullus*) sp., and an Encyrtid, *Anagyrus* sp., were introduced from the neighbouring island of Luzon. Each was liberated in colonies of 40–100 in various severely infested areas. Being small the Coccinellid could attack the bug between the leaf-sheath and the stalk. The Encyrtid oviposits in the mature or nearly mature bugs (Hadden and Lopez, 1931). Recoveries of *Scymnus* sp. and possibly of *Anagyrus* sp. were made (Lopez, 1931), but apparently no assessment of their control value was made subsequently.

Attempts to establish the Coccinellid *Cryptolaemus montrouzieri* (origin Australia), which was introduced from Hawaii in 1928, were not successful (Uichanco and Villanueva, 1932).

(39) **Gray mealybug**—*Dysmicoccus boninsis* (Kuwana) (Hem., Coccidae)

GUAM

This species at times heavily infests sugarcane shoots on Guam. The Coccinellid *Cryptolaemus montrouzieri*, introduced from Hawaii in 1926, was occasionally found to feed on this mealybug (Swezey, 1940).

(40) **White woolly aphid on sugarcane**—*Ceratovacuna* (*Oregma*) *lanigera* Zehnt. (Hem., Aphididae)

INDONESIA

In 1926 *Coelophora biplagiata* Swartz. (Col., Coccinellidae) was taken to Java from Indo-China (*via* Taiwan) for trial against *Ceratovacuna* and was distributed (Ishida, 1926). Hazelhoff (1928) stated that it was of little importance since it only increased very slowly. By transferring the native *Encarsia flavoscutellum* Zehnt. (Eulophidae) from older sugarcane fields, where it controlled the woolly aphid, to young cane fields where it was absent, and by restricting the use of insecticides, Hazelhoff (1927 *a* and *b*) was able to prevent rapid resurgence of the pest.

TAIWAN

According to Ishida (1926) surveys for natural enemies of this woolly aphid were made in South China, the Philippines, Indo-China and Indonesia. Some attempts were made to introduce *E. flavoscutellum* from Indonesia, and the Coccinellids *C. biplagiata* and a *Scymnus* sp. from Indo-China (Ishida, 1927). The first attempts to introduce *E. flavoscutellum* failed because the parasite was short-lived (Van Harreveld, 1926). Later, when taken from Indonesia in ice boxes maintaining a temperature of 12–18° C., only a few reached Taiwan alive. However, parasites bred at Hong Kong were introduced and large numbers liberated in the field but the species did not become established. *Coelophora saucia* Muls. was introduced into Taiwan from Indo-China in 1924 and distributed throughout the island. It became established in the Takao Prefecture (Ishida, 1929; Takano, 1934, 1940).

(41) **Weevil borers of sugarcane**—*Rhabdoscelus obscurus* (Boisd.) and *Trochorrhopalus strangulatus* Gyll. (Col., Curculionidae)

FIJI

The Tachinid *Ceromasia* (= *Microceromasia*) *sphenophori* Vill. (origin New Guinea) was first introduced from Hawaii in 1910 and subsequently in 1913 and 1917 from its original home, New Guinea, to control *R. obscurus*. Although it was first thought to be a failure, it became established at least in one area, where the weevil borer population decreased after 1917 (Veitch, 1921, 1926). Notes on the breeding and transportation of this parasite have been given by Illingworth (1914).

According to Windred (1936) *C. sphenophori* became well-established and distributed but failed to control *R. obscurus*, parasitism varying from 0·06 to 13·62% in 1933–34. Possible causes for this failure were the presence of predators, unfavourable climate and the inability of the parasite to locate hosts when the canes had dense foliage.

GUAM

In 1926 *C. sphenophori* was introduced from Hawaii against *R. obscurus*. The parasite became temporarily established but later failed to maintain itself (Swezey, 1940).

PHILIPPINES

C. sphenophori was introduced from Hawaii in 1928 and again in 1934 to control the reddish-brown weevil borer *Trochorrhopalus strangulatus* but it failed to become established (Uichanco, 1928; Baltazar, 1963).

SAMOA

In 1918 a colony of *C. sphenophori* was received from Hawaii and released at a Samoan village near Pago Pago harbour. It had not become established when a search was made in 1924 (Swezey, 1924).

(42) **White grubs of sugarcane**—*Adoretus versutus* Har. (Col., Rutelidae), *Anomala sulcatula* Burm. (Col., Rutelidae), *Lepidiota pruinosa* Wied. (Col., Melolonthidae), *Leucopholis irrorata* Chevr. (Col., Melolonthidae) and *Rhopaea* spp. (Col., Melolonthidae)

FIJI

Campsomeris marginella (Klug) *modesta* (Smith) (= *Scolia manilae* Ashm.) was introduced from Hawaii (origin the Philippines) in 1917 to control *A. versutus* and *Rhopaea vestita* Arrow. Over 800 adults (600 mated females) were liberated in an infested area. It was not at first thought to be established but was actually recovered five years later, 60 miles away from the point of liberation. It was believed to assist in controlling the above two species of beetles and also *R. subnitida* Arrow (Veitch, 1919 and 1924; O'Connor, 1950 *b*).

MARIANA ISLANDS (SAIPAN)

Campsomeris annulata Fabr. was introduced from the Philippines in 1940 and liberated against *A. sulcatula*. It became established and gave complete control (Yasumatsu *et al*., 1953).

PHILIPPINES

The Scoliids *Campsomeris radula* (F.) and *C. tasmaniensis* Saussure were introduced from Australia in 1931 by the Philippine Sugar Association to control white grubs *L. pruinosa* and *L. irrorata* but failed to become established. The green muscardine *Metarrhizium anisopliae* was also introduced from Queensland in 1928 although it was undoubtedly already present (Baltazar, 1963; Simmonds, 1969 *a*).

TAIWAN

Yasukawa (1924) reported the introduction of the fungus *Metarrhizium anisopliae* from Hawaii in 1914 for trials against various Lamellicorn beetles and other insects injurious to sugarcane. In experiments 25 to 33% of the adult Lamellicorns and 13 to 33% of the larvae died in soil infected with spores of this fungus. Also in the fields containing spores the number of beetles was greatly reduced.

(43) Stem-borers Egg-parasites

INDIA AND PAKISTAN

Mass-multiplication and field-liberation of the native parasite *Trichogramma australicum** was undertaken in Lyallpur (West Pakistan) and Mandya (India). The parasite was liberated against *Chilo infuscatellus* Snellen and *C. indicus* (Kapur) (Lep., Pyralidae) in India and a number of publications (Subramanyam, 1937, 1940 and 1941; Adm. Reps., Govt. Entomologist, Madras, for 1941–46, 1947–49 and 1950–51; Gupta, 1951 and Ramachandran *et al.*, 1951) document the details and results of these liberations at various places. A critical review of the results was made by a special committee, which concluded that the control of borers by *Trichogramma* has not been an economic proposition in all parts of India (Gupta, 1953). Hence the use of this parasite was given up except in Mysore State. Seshagiri Rao *et al.* (1956) reviewed this work in Mysore State and concluded that in general there was a marked increase in egg-parasitism from 0–13·5% to 62–90% in colonised plots giving worthwhile increases in yield. However, Mohanarao (1956) reported that the parasite was ineffective in Andhra Pradesh. In north India in general the parasite was reported to be ineffective, possibly because of the adverse effects of high temperature and low humidity during the summer months (Gupta, 1951).

Since field-liberations of *Trichogramma* have been continued in Mysore State Usman *et al.* (1957, 1964) reported on the protection given to sugarcane by periodical releases of the parasite. However, in north India Kapoor (1957–58) reported that the release of *T. minutum* (see footnote on page 22) against *Bissetia steniellus* (Hampson) (Lep., Pyralidae) proved ineffective.

Naturally occurring exotic species or races better adapted to the prevailing climatic conditions in the country may prove more effective than the indigenous species. Therefore, there has been renewed interest in trials with *Trichogramma* spp. in India. The CIBC Indian Station has introduced *T. japonicum* from the Philippines, *T. australicum* from Taiwan, *T. fasciatum* Perkins from Florida and Barbados and *T. perkinsi* Gir. from Colombia. These were mass-bred and released. The release of the Taiwan strain of *T. australicum* in the Pugalur area (Tamil Nadu) appears to have given over 50% parasitism of eggs of *C. indicus*. This species was also released at Mandya (Mysore State) and has been sent to other areas in India. *T. japonicum* was released at Mandya and Plassey (West Bengal) and also sent to other areas. *T. perkinsi* was released at Plassey and became quickly established.

The Scelionid egg-parasite *Telenomus alecto* Cwfd., also introduced from Colombia, has been bred and released in large numbers at Plassey. Not only have recoveries been made from sugarcane stem-borer eggs, but the parasite has also started extending its geographical range. Parasitism increased from 2–6% in 1967 to 53% in 1968. It was also released at Motipur (Bihar) from material obtained from Plassey in 1968. It was recovered in 1969. It parasitises only freshly laid eggs of *C. infuscatellus*. However, it was on one occasion reared from the eggs of *Chilo ceylonica* Hmps. on the wild grass *Vetiveria zizanioides*. It may, therefore, survive on eggs of this alternative host when eggs of *C. infuscatellus* are not available (CIBC Annual Reports).

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* This species has hitherto been referred to in the literature as *T. minutum* until the error was pointed out by Nagarkatti and Nagaraja (1968).

PHILIPPINES

T. minutum introduced from the U.S.A. in 1934 (Baltazar, 1963) was multiplied on the eggs of *Argyroploce schistaceana* (Snellen) (Lep., Eucosmidae) at the La Granja Experiment Station at La Carlota, Negros Occidental and released in small numbers (Espino, 1955). Parasitism increased from an overall average of 20·04% in 1949 to 52·60% in 1951. Espino states that in 1951 the period of borer infestation was shorter by a month than in the previous two years and he attributes this to the activity of the egg-parasite. *T. australicum* and *T. japonicum* were also introduced, the former in 1954 from Taiwan and the latter in 1934 and again in 1954 from Japan (Baltazar, 1963). In Negros Occidental, *T. australicum* was liberated periodically in large numbers against sugarcane borers. Porquez (1959) states that in years when parasites were mass-liberated, borer infestation was reduced. *T. japonicum* was also liberated in the same localities. However, this was not recovered from sugarcane borer eggs but was found to parasitise the eggs of rice stem-borers.

TAIWAN

T. australicum and *T. japonicum* were mass-bred to control sugarcane borers, using eggs of *Sitotroga cerealella* (Oliver) (Lep. Gelechiidae) and to a lesser extent of *Cadra cautella* (Wlk.) (Lep., Phycitidae) as laboratory hosts (Takano, 1933 and 1940). The effectiveness of *T. australicum* in the control of *A. schistaceana*, *C. infuscatellus* and *Chilo sacchariphagus* (Bojer)* in Taiwan has been referred to by Chen (1963), who mass-produced and liberated this species for eight years. He states that in 1960 bored cane stalks in the parasite-colonised plantations were less by 62% and bored cane joints by 80% than in the control plantations. It seems odd, however, that if this method was so successful it was discontinued. In 1965 two strains of *T. fasciatum* originating from Barbados and Florida, respectively, were introduced from India and bred in the laboratory (Chen, 1967). Results of this introduction are not available.

The 1928 report of the Sugar Experiment Station, Taiwan, states that *Telenomus beneficiens* Zehnt., introduced from Java, killed 28·5% and 26·4% of the eggs of *C. sacchariphagus* and *C. infuscatellus* in 1916 and 1918, respectively. Ishii (1940) referred to an unsuccessful attempt in 1915 to introduce into Taiwan a *Telenomus* sp. which parasitised *C. infuscatellus*, *A. schistaceana* and *Tryporyza nivella* (F.) in Java. According to Takano (1940) *T. beneficiens* became so adapted to the eggs of *C. infuscatellus* in the laboratory that it would no longer attack those of *C. "sacchariphagus"*.

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* Bleszynski (1969) does not include Taiwan in the distribution of this species. However, according to him *Chilo venosatus* Wlk. occurs in Taiwan and it is likely that this is synonymous with *sacchariphagus*.

Homenopterous larval parasites

INDIA

Puttarudriah and Sivashankara Sastry (1959) mentioned the release of 32,700 adults of the indigenous Eulophid pupal parasite *Tetrastichus ayyari* Rohwer to control sugarcane borers in Mysore State during 1950–55. However, the parasite was not recovered.

A plea to introduce exotic parasites for trial was first made by Gupta (1954). Two New World species, *Ipobracon puberuloides* Myers and *Apanteles diatraeae* Mues. (Braconidae) (the latter in sufficiently large numbers) were introduced in 1959 by the CIBC Indian Station from Trinidad through the West Indian Station. In laboratory experiments both failed to parasitise the Indian species of borers. In 1964 field-collected adults of *Agathis stigmaterus* (Cress.) (Braconidae) were obtained from the U.S.A. for trial, but again this failed to parasitise the Indian borer species. In addition a few field-collected cocoons of *Angitia* (*Dioctes*) *lineata* (Ishida) (Ichneumonidae) were obtained from Taiwan but it was impossible to breed them. Other parasites obtained for trial were *Apanteles chilonis* from Japan and *A. sesamiae* from East Africa. Both were bred in the laboratory and sent to Nellikuppam and Pugalur (Tamil Nadu), Ludhiana (Punjab), Motipur (Bihar) and Plassey (West Bengal). These have been released at all these places except Ludhiana where only *A. chilonis* was liberated. No recoveries have been made so far.

INDONESIA

Attempts were made to import the Ichneumonid *Centeterus alternecoloratus* Cushm. into Java from China in 1929–30, since it was thought to be promising against sugarcane and rice stem-borers but the adult parasites emerged and died in transit. However, from the same shipment some *Bracon chinensis* Szep. emerged and these were bred in Java on different borers of both sugarcane and rice. Small numbers were released in the field in 1930 (Van der Goot, 1948 *a*), but the results are not known.

TAIWAN

Takano (1940) referred to the introduction of an undetermined Braconid from the Philippines in 1928 against *A. schistaceana* but there was no subsequent mention of its establishment. This was probably *Spathius fuscipennis* Ashm., originally introduced into Japan from the Philippines in 1928 for trial against the rice stem-borer *Chilo suppressalis* (Ishii and Mizutani, 1934).

Introduction of hymenopterous larval and pupal parasites into Taiwan in recent years to control sugarcane borers has been mostly through the CIBC Indian Station. The parasites sent to Taiwan during 1961–69 include: (1) *Goniozus indicus* Muesebeck (Bethylidae), (2) *Goniozus* sp., (3) *Bracon hebetor* (Say) (a strain parasitising *Sesamia inferens* Walker) and (4) *Trichospilus diatraeae* Cherian and Margabandhu. According to Chen and Hung (1962) *G. indicus* was reared on *C. infuscatellus* in the laboratory. Chen stated recently (personal communication) that *B. hebetor* and *T. diatraeae* were also reared in the laboratory, but establishment in the field has apparently not been successful.

Dipterous larval parasites

INDIA AND PAKISTAN

Efforts have been made with exotic Tachinid parasites, particularly *Lixophaga diatraeae* Tns. and *Diatraeophaga striatalis* Tns. Except for the recovery of *L. diatraeae* on two occasions none of the introduced species has become established. Five strains of *L. diatraeae* (from Cuba, Jamaica, Dominican Republic and Antigua in 1959–60, and Trinidad—the last of these through the courtesy of Mr. C. B. Chen of the Taiwan Sugar Experiment Station, Taiwan in 1963–64), two strains of *Paratheresia claripalpis* (in 1959–60 and 1968), *Metagonistylum minense* (in 1959–60) and *Palpozenillia* sp. (in 1968–69) from the CIBC West Indian Station, and *D. striatalis* (obtained by the CIBC Pakistan Station from Indonesia in 1961 and by the CIBC Indian Station from Malagasy in 1965) were introduced into India for trials. Laboratory trials of *L. diatraeae* using the Indian stem- and top-borers of sugarcane were conducted by Mohanraj and Saxena (1964), Saxena and Dayal (1965) and Jai Rao (1967). The parasite was liberated in north India (Lucknow, Plassey, Shahjahanpur) and south India (Mandya, Nellikuppam, Pugalur and Vadapathimangalam) and was recovered once both at Lucknow and Mandya. Similar releases by CIBC Pakistan Station gave negative results. *D. striatalis* was bred and liberated in south India. No recoveries have been made. No releases were made in Pakistan. *P. claripalpis* was not liberated because in laboratory tests it did not readily parasitise the Indian sugarcane borers. *Palpozenillia* sp. gave reasonably good parasitism but sufficient numbers for field release were never available.

PHILIPPINES

L. diatraeae was obtained in 1958 from Trinidad and again in 1960–61 from Taiwan since there were no survivors in the first shipment. In the laboratory, the Tachinid was bred on *Chilo suppressalis* but no field releases were made (Baltazar, 1963).

TAIWAN

Ishida (1927) introduced *D. striatalis* from Java in 1916 but apparently it was not established (Takano, 1940). Uichanco (1928) mentioned that Takano spent four months at Los Banos in the Philippines in 1928 to obtain a Tachinid parasite of *A. schistaceana*. Takano (1940) also mentioned the introduction of an unspecified Tachinid. Apparently this parasite too did not become established. *L. diatraeae* was obtained from the U.S.A. in 1955 but could not be bred. In 1956–57 more material was introduced from Trinidad with the assistance of the CIBC Station there and a culture was built up at the Taiwan Sugar Experiment Station, using larvae of the grain-moth *Brachmia modicella* Christoph. (Lep., Gelechiidae) as the laboratory host (Chen, 1959; Chen and Hung, 1960). Field liberations at three different stations produced 32·6%, 9·8% and 11·4% parasitism, respectively of *C. infuscatellus*, *C. venosatus* and *S. inferens* (Estioko, 1962). However, further observations in subsequent years have shown that the parasite was unable to maintain its population permanently in the field.

In 1962 and 1963 the Tachinid *Sturmiopsis inferens* was introduced from India. It was released in 16 plantations to control *Sesamia inferens* and recovered in three of them. Although established, it gave very low parasitism (Chen, 1967).

Predators

Few investigations have been carried out on predators of sugarcane borers (Jepson, 1954). Most of the records of predators invariably refer only to accidental encounters of predators with borers. Their actual value in the biological control of sugarcane borers, therefore, is uncertain.

TAIWAN

Yanagihara (1934) and Takano (1940) mentioned the use of the ants *Tetramorium guineense* F. and *Pheidole* spp. against *S. inferens* larvae in the field. Takano and Yanagihara (1939) stated that in one district of Taiwan *Tetramorium* was distributed in sugarcane fields in pieces of bamboo.

(44) **Top-borer**—*Tryporyza nivella* (F.) (earlier under *Scirpophaga*) (Lep., Pyralidae)

INDIA

The indigenous Ichneumonid parasite *Isotima javensis* (Rohw.), (misdetermined as *Melcha ornatipennis* (Cameron) was multiplied in the laboratory and released at Mandya (Mysore State) in 1960 to control the top-borer (Puttarudriah and Usman, 1961; Usman *et al.*, 1964). This parasite was also released in Pugalur (Tamil Nadu) in 1958 and releases were continued up to 1964. As a result of these releases the incidence of top-borer declined from 37·4 to 10·8% and parasitism reached 52% on one occasion (Raja Rao, personal communication).

Puttarudriah and Sivashankara Sastri (1959) reported that *Tetrastichus ayyari* was reared in the laboratory on *T. nivella* and released against this borer at various places during 1950–55. No recoveries were made.

TAIWAN

According to Lee and Chiu (1961) *Telenomus beneficiens* var. *elongatus* Ishida imported by Ishida in 1915 from Java has become established and is the most important egg-parasite in Huwei district, the overall parasitism being 66·77%.

I. javensis was introduced from India through the CIBC Station there and bred on a large scale. It was liberated in 17 plantations at the rate of 10–48 adults each during 1961–62 and recoveries were made from 9 plantations in 1962, parasitism reaching a maximum of 18·8% (Chen and Hung, 1962 and 1963). *Rhaconotus scirpophagae* Wlkn. and *Rhaconotus* sp. nr. *signipennis* Wlk. (Braconidae) were also introduced from India during 1961–66 but without success.

INDONESIA

I. javensis was obtained from India during 1954–56 under the mistaken name of *Melcha ornatipennis* (Dresner, 1958). Only 10 females emerged from the material received. It is not known if these were liberated. However, following correct determination the parasite was already known to be present in Java.

Tea

Many pests are known to attack tea in South-East Asia. Attempts have been made to use natural enemies against three of these in Ceylon, Malaysia and India, but there is considerable scope for exploring further the possibilities of biological control of pests of this important plantation crop.

(45) **Tea tortrix**—*Homona coffearia* Nietn. (Lep., Tortricidae)

CEYLON

The tea tortrix *H. coffearia* is a serious pest both of coffee and tea. In 1932 the egg-parasite *Trichogramma evanescens* Westw. was imported through the Imperial (now Commonwealth) Institute of Entomology, London. It was bred on *Corcyra cephalonica* and *Anagasta* (*Ephestia*) *küehniella* Zeller (Pyralidae) and released in 1934 in areas where tortrix infestation was heavy, when in field experiments it gave up to 60% parasitism. The parasite decreased steadily in subsequent generations and failed to control *H. coffearia.* Failure was attributed to the incompatibility of the length of its life-cycle with that of the host, such that host eggs were not available in adequate numbers and at the proper time in the field to maintain the parasite population (King, 1933, 1934, 1935).

In 1930 two shipments of *Trichogrammatoidea nana* (Zehnt.) were received from Malaya but this species could not be bred after one generation. In the same year *Trichogramma minutum* was received from California but all the parasites were dead on arrival (King, 1931).

During 1935 a species of *Macrocentrus* was introduced from Indonesia and 378 adults out of 488 received were released directly in infested fields. From another shipment received in 1936, 117 parasites were released (King, 1937). This species was later described by Nixon (1938) as *Macrocentrus homonae.* It was able to survive in the field even during the South-West monsoon when *H. coffearia* was scarce. By 1937 it had spread over an area of 200 square miles, parasitism ranging from 50 to 100% as compared with a total parasitism of 5% by all the local parasites (King, 1937, 1939). The parasite is polyembryonic and has been able to reduce the pest to one of minor importance (Gadd, 1941, 1946).

In 1960 Simmonds reported that *Homona* was formerly a serious pest in Ceylon and that the introduction of *M. homonae* from Indonesia had given complete control. There were occasional minor outbreaks of the pest which are probably associated with insecticidal treatment against *Xyleborus fornicatus* Eich. (Simmonds, 1960).

(46) **Tea mosquitoes**—*Helopeltis* spp. (Hem., Miridae)

MALAYSIA

Species of *Helopeltis* are widespread pests of tea (popularly known to planters as 'tea mosquitoes') in the Indo-Malayan region. In Malaysia *H. bradyi* Waterh. and *cinchonae* Mann are common in the Cameron Highlands where tea is grown. In 1940 the following Reduviid predators were introduced there from the lowlands: *Euagorus plagiatus* Burm., *Rhinocoris marginellus* Thnb., *Sycanus leucomesus* Wlk., *Isyndus heros* F. and *Cosmolestes picticeps* Stål. The last three appeared to have become established. Three other species, *Endochus cameronicus* Miller, *Isyndus* sp. and *Euagorus* sp., which were already known to attack *Helopeltis* in the highlands, were also bred and liberated. The extent to which these predators controlled the pests is uncertain (Rep. Dept. Agric., Malaya, 1940; Corbett and Pagden, 1941).

(47) **Tea-mites**

INDIA

An attempt was made in 1961 by the CIBC Indian Station to introduce the Coccinellid *Stethorus vagans* Blackburn from Australia for trial against the tea-mites *Calacarus carinatus* Green and *Brevipalpus californicus* (Banks) and the red spider *Oligonychus coffeae* Nietner. Some 45 beetles were released in a tea estate at Coonoor in the Nilgiris but no recoveries were made. Efforts to introduce the predacious mite *Typhlodromus newsami* Evans from Malaysia were also unsuccessful because of heavy mortality in transit (Rao *et al.*, 1970).

Miscellaneous Pests of Agricultural Importance

(48) **Locusts**

PHILIPPINES

Attempts to control the migratory locust *Locusta migratoria manilensis* (Mayne) by *Coccobacillus acridiorum* d'Herelle and the birds *Aethiopsar cristatellus* L. and *Acridotheres tristis* L. in the Philippines have been reported. *C. acridiorum*, which was said to be successful in controlling locusts in Argentina, was obtained from there in 1913. It was cultured in the laboratory but when applied in the field it failed to control the locusts (Baltazar, 1963).

Several attempts were made by the Spanish Government around 1850 to have the Chinese starling *A. cristatellus* established against the migratory locust. This bird was introduced either from India or from China. It became established on Luzon and is one of the most abundant species of birds there. Although it did not give any significant control of locusts, it has helped in reducing the incidence of *Spodoptera mauritia*. The bird is beneficial in so far as it feeds mostly on harmful insects and wild fruits. But when the insects and wild fruits become scarce, it may become harmful to cultivated fruit trees. Being hardy and prolific it is believed that this exotic bird may have caused some decrease in the native species of birds. In 1940 and 1941 this bird was also introduced into some other Provinces. It is not known whether it has become established there (Soriano, 1954; Baltazar, 1963).

Uichanco (1928) also mentioned the introduction of 9 young mynah birds, *A. tristis*, from Hawaii (origin India). According to Baltazar (1963) the species did not become established in the Philippines.

(49) **Aphids**

GUAM

Peterson (1956 *c*) mentions the introduction of the Coccinellids *Orcus chalybaeus* (Boisd.) and *Platyomus lividigaster* (Muls.) from Hawaii in 1953 to control aphids. There is no evidence of their establishment.

PHILIPPINES

Aphidius (*Lysiphlebus*) *testaceipes* (Cress.) (Hym., Braconidae) was introduced from Hawaii in 1956 for trial against aphids. Only 260 adults which survived the journey were liberate in three places. Again in 1960, two shipments of parasite adults and mummified aphids (parasitised by *Aphidius*) were received from Hawaii. The adults were liberated in Cebu City among *gabi* or taro plants heavily infested with aphids. Those that emerged from mummified aphids were not liberated because several secondary parasites were noticed among them. The species has not been recovered from any of the liberation sites (Baltazar, 1963).

The Coccinellid *Hippodamia convergens* Guer. was introduced from the U.S.A. in 1953 and was released on Luzon and Mindanao against aphids feeding on beans, citrus, sugarcane and tobacco. It did not become established because of the hot climate and its habit of overwintering in the snow. Moreover, in the field the beetles were attacked by the red fire-ant *Solenopsis geminata* Jerdon (Baltazar, 1963).

(50) **Cottony-cushion scale**—*Icerya purchasi* Mask. (Hem., Coccidae)

CEYLON

I. purchasi was common in 1915 when an area of *Acacia decurrens* Willd. was found badly infested. The scale spread rapidly during 1916–17. In 1918 *Rodolia cardinalis* (origin Australia) was imported from South Africa and a few beetles that arrived alive were liberated. As there was no sign of its establishment, 400 adults were again obtained in 1919 but none arrived alive. However, 50 of the 300 adults received in 1920 were alive and from this stock a large number were bred and liberated in various localities. The scale population was very much reduced by the predator (Hutson, 1920).

GUAM

R. cardinalis was introduced into Guam from Hawaii in 1926 and brought about complete control of the cottony-cushion scale (DeBach, 1964).

HONG KONG

R. cardinalis and *Cryptolaemus montrouzieri* (origin Australia) were introduced from India through the CIBC Station in 1961 and 1962, respectively, for trial against *I. purchasi* on casuarina (and other plants, including citrus). *R. cardinalis* was successfully bred and up to 1,000 adults were liberated at Castle Peak Farm and Yau Yat Tsuen in 1962. It was recovered in large numbers at Castle Peak and Kowloon in 1967 and *C. montrouzieri* at Au Tau in 1966. Both species effectively controlled the cottony-cushion scale on citrus (R. I. Leather, pers. com.; Ann. Dept. Rep., Dir. Agric. & Fisheries, Hong Kong, 1967–68).

INDIA

I. purchasi was first reported from the Nilgiris (South India) in 1928 as a pest of cultivated wattle, *Acacia decurrens* and other *Acacia* spp. (Ramachandra Rao and Cherian, 1944). Subramanyam (1955) lists 117 hosts of this insect. As the pest posed a serious threat to fruit and other trees of economic importance steps were taken to control it biologically, since chemical methods of control were too expensive.

In 1929 two consignments of *R. cardinalis* (origin Australia) were received, one from South Africa and another from California, through the Farnham Royal Parasite Laboratory of the Commonwealth Institute of Entomology, and a third in 1930 from Egypt. A total of

4,000 beetles were liberated in the Nilgiris during 1930. The pest was soon brought under control, but in 1941 again assumed serious proportions and spread to the Upper Palni hills. The predator was multiplied at Kodaikanal in 1942 and 1943, and 5,817 adults were liberated, again resulting in control of the pest (Ramachandra Rao and Cherian, 1944).

With the spread of the pest to Mysore, Coorg, Travancore and Bombay, the citrus crop in these states was seriously threatened. A substation for multiplication and liberation of *Rodolia* was set up at Kodaikanal with stocks obtained from the Nilgiris and New Zealand. Over a period of several years many thousands of adults were released in infested localities, in small batches and at intervals, resulting in effective control of the pest (Adm. Reps., Govt. Entomologist, Madras, 1942–43, 1944–49; Subramanyam, 1955).

Consignments of cottony-cushion scale parasitised by *Cryptochaetum iceryae* (Williston) (Dip., Cryptochaetidae) were received from California, U.S.A., in 1947 and 1948. Some 200 parasites obtained were liberated in the field and 440 in field cages with scale-infested host plants but no establishment occurred (Subramanyam, 1949).

PHILIPPINES

In 1956 seven adults of *R. cardinalis* collected in Hawaii were brought to the Philippines. The 4 survivors were liberated in Manila. It is doubtful that the species survived. Further introductions may be made to control *Icerya* on citrus and coconuts (Baltazar, 1963).

(51) **Other scale insects and mealybugs**

COOK ISLANDS

A mealybug, *Pseudococcus* sp., attacking *Pandanus* and *Hibiscus tiliaceus* L. was mistaken to be a "white aphis" similar to the woolly aphid *Eriosoma lanigerum* and *Aphelinus mali* was introduced from New Zealand in 1928, 1929 and 1941. The parasite failed to become established.

A species of mealybug parasite, probably *Coccophagus gurneyi* Comp. (origin Australia), was introduced from New Zealand in 1934. In 1935 *Cryptolaemus montrouzieri* (origin Australia) was identified in a sample of mealybugs collected near the liberation sites indicating that this predator had also been introduced. The exact date of this introduction is not known. *C. gurneyi* was apparently not recovered.

In 1954 an *Aphytis* sp. and *Chilocorus bipustulatus* (L.) (a Palaearctic species) were imported from California to control the purple scale *Lepidosaphes beckii* Newm. An unknown number of *Aphytis* and 56 adults of the predator were liberated in Aitutaki. From field observations it appears probable that both species are established but reliable determinations of the material collected have not been made (unpublished report, Dept. of Agriculture, Cook Islands).

FIJI

About a dozen specimens of the ladybird beetle *Azya luteipes* Muls. (origin Trinidad) were introduced from Hawaii and released on a patch of *Lecanium*. It is not known to be established (Simmonds, 1929 *a*; O'Connor, 1950 *b*).

GUAM

In 1954 a number of natural enemies were introduced from the U.S.A. against *Saissetia hemisphaerica* (Targ.) and *S. nigra* (Niet.). They included *Aphycus helvolus* Comp. (Encyrtidae), *A. lounsburyi* How., *A. luteolus* Timb., *A. stanleyi* (Comp.), *Coccophagus lycemnia rusti* (Comp.) (Aphelinidae) and *Scutellista cyanea* Motsch. (Pteromalidae). *A. helvolus*, *A. lounsburyi* and *S. cyanea* have become established but the establishment of others is uncertain (Peterson, 1956 *c*).

Peterson also mentions the introduction of *Orcus chalybaeus* from Hawaii in 1953 for trial against scales. It is not known whether this Coccinellid became established.

In 1948 a *Rodolia* sp. attacking *Icerya aegyptiaca* (Dougl.) in India was introduced from there and released against the same species of mealybug (also released on one of the Marshall Islands). The predator does not appear to be established (Gardner, 1958).

INDIA

Attempts to use the native *Chilocorus nigritus* (F.) (Col., Coccinellidae) to control *Coccus* (*Lecanium*) *viridis* (Green) on coffee in summer were unsuccessful. Trial liberations in other seasons showed that *Chilocorus* could usefully supplement chemical control. The predator also helped in preventing reinfestation of coconuts by *Aspidiotus destructor* and of citrus by *Parlatoria zizyphus* Lucas and *Aonidiella aurantii* (Mask.) after spraying with non-persistent insecticides (Tirumala Rao *et al.*, 1954).

Cryptolaemus montrouzieri was introduced in 1898 from Australia by Mr. H. O. Newport, an amateur entomologist and coffee planter of the Lower Palnis (Madurai District). He brought a consignment of 1,500 *C. montrouzieri*, 2,540 *Orcus australasiae* Boisd. and 246 *Rhizobius ventralis* Erich. in ice chests and liberated them in his estate to control *C. viridis* (Puttarudriah *et al.*, 1952; Mayne, 1953). Although *C. montrouzieri* was subsequently recovered from a number of localities in south India it has not been effective against *C. viridis*. The other species have not become established. *C. montrouzieri* is now a common mealybug predator in south India.

C. montrouzieri has been bred on the cochineal insect *Dactylopius opuntiae* (Ckll.) in the laboratory and successfully used to control *Pulvinaria maxima* Green on neem, *Centrococcus insolitus* (Green) on brinjal, *P. psidii* Mask. on guava and sapota, and *Pseudococcus corymbatus* Green on citrus in south India (Tirumala Rao and David, 1958).

Recently the predator was released several times at Burnihat (Assam) to control citrus mealybugs and scale insects but it did not become established (Narayanan, 1967).

C. montrouzieri and the indigenous Coccinellid *Scymnus* (*Pullus*) *coccivora* Ayyar were sent by the CIBC Indian Station to Sikkim, where field releases were made in citrus orchards but recoveries have not yet been made.

INDONESIA

Van der Goot (1920) introduced *C. montrouzieri* (origin Australia) from Hawaii into Java to combat the "lamtoro scale" *Ferrisia virgata*. Along with this, *Rhizobius ventralis* and *Scymnus biguttatus* Muls. were also introduced. However, these two Coccinellid species died without reproducing. *C. montrouzieri* was bred in large numbers and liberated in 1918. Observations during the next two years showed that it was able to breed naturally in Java. However, only small numbers were seen and the scarcity of scales during the rainy season seemed to be a limiting factor. Van der Goot maintained that without artificial assistance (*i.e.*, fresh liberation at the beginning of the dry season) *C. montrouzieri* could not become really valuable in Java.

PHILIPPINES

C. montrouzieri was obtained from the U.S.A. for trial against mealybugs during 1928–31. About 3,000 laboratory bred adults were released at Los Banos and at various altitudes up to 1,000 metres on Mt. Maquiling. Releases were also made at other places. It became established only on pineapple mealybugs at Bukidnon. Another attempt to introduce this predator was made in 1956. Over 100 adults obtained from Hawaii were released in Manila and Los Banos. It was not recovered from any of these places (Baltazar, 1963).

Two other Coccinellids, *Diomus margipallus* (Muls.) and *Hyperaspis silvestri* Weise and *Silvestrina koebeli* Felt (Dip., Cecidomyiidae) were imported from Hawaii in 1934 for trial against pineapple mealybugs. In 1956 four adults of *Scymnus bipunctatus* Kugelann, 7 *S. notoscens* (Blackburn) and 11 *Coelophora pupillata* (Schon.) (Coccinellidae) were brought from Hawaii and released in the field. *S. bipunctatus* was already known to occur in the Philippines while the fate of the other introduced species is not known (Baltazar, 1963).

TRUST TERRITORY

I. aegyptiaca is a serious pest of avocado, banana, citrus and other economic plants on some islands of the Trust Territory. Investigations showed that the pest was held in check by the predator *Rodolia pumila* Weise in the Mariana Islands and by a closely related Coccinellid in the Palau Islands. From 1947 to 1949 *R. pumila* was collected in the Marianas and released on several islands of the Carolines where the mealybug was abundant. It became established on all the islands and gave satisfactory control. In 1953 colonies of the related species from the Palaus were liberated on one island in the Eastern Carolines and on some of the Marshall Islands. Whether it became established on any of these is not known (Gardner, 1958).

(52) **Green vegetable bug**—*Nezara viridula* L. var. *smaragdula* (F.) (Hem., Pentatomidae)

COOK ISLANDS

In 1950 four adults of an egg-parasite, *Asolcus* (*Microphanurus*) *basalis* (Woll.) (Hym., Scelionidae) (origin Egypt), which survived in a shipment received from New Caledonia (?) were liberated. There is no indication that this parasite is established (unpublished report, Dept. of Agriculture, Cook Islands).

FIJI

Biological control of *N. viridula* has been attempted in Fiji, where its main host plants are tomato and beans. *A. basalis* was introduced from New South Wales in 1941. It was bred and liberations were made in four areas on Viti Levu. Some 11,000 individuals were liberated in Suva and 350 were sent to Tonga. The parasite was also released on Rabe, Taveuni and Lau Islands. It has become established in Fiji but there is no indication of its control value (Lever, 1941 *b*, 1942 *a*, *b* and *c*; O'Connor, 1950 *b*).

A consignment of adults of *N. viridula* parasitised by the Tachinid *Trichopoda pennipes* was received from Florida in 1940 but only a few parasites emerged and they died without mating (Lever, 1941 *a*). In 1949 a shipment of 100 puparia was again obtained from Florida through the CIBC West Indian Station. In Florida this Tachinid parasitises Pentatomid and Coreid bugs. In Fiji it was bred through several generations, mainly for shipment to the Solomon Islands for trial against *Amblypelta cocophaga*. However, 50 males and 60 mated females were released at Nasinu in 1950. Small numbers were also liberated in the vicinity of Naduruvloulou, and one lot of 200 parasitised *N. viridula* was sent to Labasa on the island of Vanua Levu. Although in 1950 a male *T. pennipes* was reared from a field-collected bug and eggs of the parasite were found on an adult *N. viridula* collected in the field, the parasite has apparently not become permanently established in Fiji (O'Connor, 1960 *b*).

TONGA

Following the successful introduction of *A. basalis* from Fiji in 1941 (see above) the pest has become considerably reduced in importance (O'Connor, 1949).

(53) **Taro leafhopper**—*Tarophagus proserpina* (Kirk.) (Hem., Delphacidae)

GUAM

The egg-feeding mirid *Tytthus* (*Cyrtorhinus*) *fulvus* Knight was introduced from Hawaii (origin Philippines) and released on Guam in 1947. It became established and brought the leafhopper under control. Later, adults were sent from Guam to Ponape "with good results" (Gardner, 1958).

(54) **Lady-bird beetles**—*Epilachna* spp. (Col., Coccinellidae)

GUAM

In 1948 *E. philippinensis* (Dke) became serious on various Solanaceous vegetable crops on Guam and also on the adjacent islands of Saipan, Tinian and Rota. A Tachinid parasite, *Paradexodes epilachnae* (Aldr.), which attacks *Epilachna varivestis* (Muls.) in Mexico, was introduced from that country in 1950 and 1952. In 1950 approximately 3,100 puparia were received and the adults were liberated over 22 areas of the island. From a total of 1,800 puparia received in 1952, only 438 adults could be liberated. No recoveries have been made. In 1954 the Eulophid *Pediobius* (*Pleurotropis*) *epilachnae* (Rohw.) was obtained from the Philippines, bred in the laboratory and 24 colonies comprising more than 3,000 parasites were liberated. The parasite became established and proved to be very effective in controlling the beetle, giving an average of 72% parasitism of the pupae of *E. philippinensis* (Peterson, 1956 *b*; Gardner, 1958).

INDIA

The indigenous *P. epilachnae* was bred and liberated against *Epilachna* sp. on brinjal in Madras State (now Tamil Nadu) with some success. In one case the initial field parasitism was 12% and it increased to 80% within a week after parasite release. The parasite is very specific to *Epilachna*, which is seasonal in occurrence. Attempts to preserve the various stages in cold storage have not been successful (Adm. Rep., Govt. Entomologist, Madras, 1947–48).

(55) **Chinese rose-beetle**—*Adoretus sinicus* (Burm.) (Col., Rutelidae)

GUAM

A. sinicus was found on Guam in 1949 and later on several other islands in the Marianas. Believed to be an introduction from Hawaii, it soon became a serious pest of various food and ornamental plants on Guam. In 1950 and 1951 *Campsomeris marginella modesta* was introduced from Hawaii (origin Philippines) to control the beetle. Although the parasite became established, its effectiveness as a control agent has not been evaluated (Gardner, 1958).

(56) **Soybean beetle**—*Phaedonia inclusa* (Stal.) (Col., Chrysomelidae)

INDONESIA

Schizonotus latus (Walker) (Hym., Pteromalidae), an important parasite of the willow leaf beetle *Plagiodera versicolora* (Laich.) (Chrysomelidae) in the U.S.A., was thought to be a potential parasite of the soybean beetle *P. inclusa* and was imported in 1956. About 100 adults were liberated in a soybean field in East Java and about 50 in a field of *Desmodium* sp., which is also attacked by *Phaedonia*, in West Java. There is no evidence of establishment (Dresner, 1958).

(57) **Fruit-flies**—*Dacus* spp. (Dip., Tephritidae)

Fruit-flies inflict heavy losses on vegetable and fruit crops in several countries but efforts to control them by means of natural enemies have only been made in Ceylon, Cook Islands Fiji, Guam and Saipan, and the Philippines in the region covered by this review.

CEYLON

The first introductions made into Ceylon were of the pupal parasites *Spalangia* sp. (Hym., Pteromalidae), parasitising *Dacus ferrugineus* F., from Malaya and *Dirhinus auratus* Ashm. (Hym., Chalcididae), parasitising *D. cucurbitae* Coq., from south India. Breeding and liberations were continued during 1937 and 1938 and both species became established in cucurbit fields, though parasitism of *D. cucurbitae* was low, but not in *Citrus* areas where they were released against *D. ferrugineus* (Hutson, 1939 *a*, *b*). In 1955 introductions of the Braconids *Opius oophilus* Full., *O. longicaudatus* (Ashm.) var. *taiensis* Full., *O. l.* var. *novacaledonicus* Full., *O. formosanus* (Full.) and *O. compensans* (Silv.) were made from Hawaii. These parasites were liberated at Nalanda and Palwehara (Fernando, 1955) but there has apparently been no follow-up of the results.

COOK ISLANDS

The following parasites were introduced against *Dacus melanotus* Coq.:

Year	*Species*	*From*	*Number liberated*
1927	*Opius tryoni* Cam. (origin Australia) ..	Hawaii	49 (only 1 female), species not known.
1927	*O. humilis* Silv. (origin Africa) ..	Hawaii	
1927	*Tetrastichus* sp. ..	Hawaii	18
1936	*Tetrastichus giffardianus* Silv. (origin Africa)	Fiji	?
1938	*Tetrastichus* sp. ..	Fiji	11, species not known.
1938	*Dirhinus* sp. ..	Fiji	
1938	*Dirhinus* sp. ..	Fiji	150
1938	*Aceratoneuromyia* sp. ..	Fiji	42

There is no definite evidence of establishment of these parasites but an investigation in 1960 showed that the pest was very scarce in Rarotonga and absent from Aitutaki (unpublished report, Dept. of Agriculture, Cook Islands).

FIJI

Dacus passiflorae Frogg. and *D. xanthodes* Broun are important pests in Fiji. *T. giffardianus* (Eulophidae) and *Opius humilis* were introduced from Hawaii in 1935, *Dirhinus giffardii* Silv. from India in 1937 and *Aceratoneuromyia indicum* (Silv.) (Eulophidae) from New South Wales (origin India) in 1938. None of these introductions resulted in successful control of the fruit-flies, although *T. giffardianus* and *A. indicum* were both recovered (Simmonds, 1935 *a*; 1936, Lever, 1943 *a*; O'Connor, 1950 *b*).

In 1951 *Opius vandenboschi* Full., *O. oophilus*, *O. longicaudatus* and *O. incisi* Silv. were obtained from Hawaii. Liberations made comprised 7,000 *O. vandenboschi*, 650 *O. oophilus* and a few *O. longicaudatus* and *O. incisi*. Further stocks of *O. longicaudatus* were received in 1954 and 928 of the former and 726 of the latter were liberated. The latter species was bred on *D. passiflorae* and a further 2,463 were liberated. These two *Opius* species became established on the island of Veti Levu and following this infestation by fruit-flies was considerably reduced. *O. oophilus* was the more important and appears to have played a significant part in controlling the fruit-flies (O'Connor, 1954 and 1960 *a*, *b*).

GUAM AND SAIPAN

Between 1950 and 1955 several consignments of parasites were obtained from Hawaii and released on Guam and Saipan to control *Dacus dorsalis* Hend. These included *O. compensans*, *O. formosanus*, *O. incisi*, *O. longicaudatus*, *O. persulcatus* (Silv.), *D. giffardii* and

A. indicum. *Opius watersi* (Full.) and *O. fletcheri* Silv. were also introduced from Hawaii and released against *D. cucurbitae*. There is no indication whether these have become established (Peterson, 1956 *c*; Gardner, 1958).

PHILIPPINES

A number of *Opius* spp. were introduced from Hawaii from 1923 to 1957 to control *D. cucurbitae* and *D. dorsalis*. These included: *O. fletcheri* which became established around Manila and gives partial control of *D. cucurbitae*; *O. humilis*, *O. compensans*, *O. formosanus* and *O. l. taiensis*, none of which became established; and *O. oophilus* which became established at Los Banos and *O. l. novacaledonicus*, not established.

D. giffardii was also introduced from Hawaii in 1958. No efforts were made to check if the parasite has become established (Baltazar, 1963).

(58) **Castor semi-looper**—*Achaea janata* (L.) (Lep., Noctuidae)

INDIA

The reports of the Madras Agriculture Department for the years 1942–44 mention large-scale multiplication and release of *Trichogramma* sp. (see footnote on page 22) against *A. janata*. However, these efforts do not appear to have provided satisfactory control of the pest.

In 1964 the CIBC Indian Station imported a *Telenomus* sp. (Scelionidae) from New Guinea where it parasitises the eggs of *A. janata*. It was multiplied in the laboratory at Bangalore and cultures were sent to Hyderabad (Andhra Pradesh) for breeding and field-liberation. This *Telenomus* sp. is reported to have given 60 to 80% parasitism in cages under field conditions. *Telenomus nawai* Ashm. a parasite of *Spodoptera litura* was also imported from New Guinea but it did not attack *A. janata*.

In a field trial using *Bacillus thuringiensis* Kulshrestha *et al.* (1965) obtained 80% mortality of the larvae over an acre of heavily infested castor.

(59) **Cutworms**—*Agrotis ypsilon* (Rottemburg) and **Semi-looper**—*Plusia* sp. (Lep., Noctuidae)

INDONESIA

The Tachinid parasites *Goniophana heterocera* Macq. and *Acuphocera varia* F. and the Braconid *Apanteles ruficrus* Hal. were introduced into South Celebes from Java in 1929. In all 1,154 adults, mostly *G. heterocera*, were liberated, but it is not known if they have become established (Franssen, 1935).

PHILIPPINES

In 1934 the Ichneumonid *Hyposoter* sp. was introduced from Hawaii against *Plusia* sp. but it did not become established (Baltazar, 1963).

(60) **Spodoptera litura (F.)** (Lep., Noctuidae)

INDIA

A consignment of the Protozoan *Microsporidium polyhedricum* Bolle (origin Austria) in dead silkworms was received from Egypt, where this organism was said to be effective in controlling *S. litura*, but experiments at Pusa during 1913–14 gave negative results with larvae of *S. litura* (Dudgeon, 1913; Fletcher, 1914).

INDONESIA

A polyhedrosis virus obtained from *Spodoptera* sp. in Ceylon was sent to Bogor in 1957. However, it was not tried on the local species of *Spodoptera* (Dresner, 1958).

(61) **Heliothis** spp. (Lep., Noctuidae)

INDIA

Many economic plants are attacked by *H. armigera*, those preferred in India being *Cicer arietinum* L. and *Lycopersicon esculentum* Mill. Majumder *et al.* (1957) gave an account of trials with a strain (HB III) of *Bacillus thuringiensis* against *H. armigera*. It was isolated in 1955 from dying pod-borer larvae (? *Adisura atkinsoni* Moore) found on *Dolichos lab-lab* L. in Mysore. In field tests spraying heavily-infested plants with 3,000–5,000 vegetative cells per sq. inch reduced infestation by about 50% or more in seven days, and resulted in complete or almost complete mortality of the larvae after another six days. Infestation was also somewhat reduced in adjacent untreated plots, about 35–40% larvae collected from them showed symptoms of the disease and about 25–35% died in six days. Releasing infected larvae on host plants in order to spread the bacillus to healthy larvae was much less effective. Spraying the plants with spore suspension reduced *Heliothis* infestation by over 95% in a week. However, these experiments have not led to any practical application of the method on a large scale.

Four shipments consisting of a total of 4,000 puparia of the Tachinid *Eucelatoria* sp. were obtained by the CIBC Indian Station from the U.S.A. in 1969. There was emergence and heavy mortality of adults *en route* and only 1,600 puparia and 500 adults arrived in good condition. Field-releases were made as follows: 28 mated females and 5 males at Coimbatore (Tamil Nadu), 40 adults at Pipariya (Madhya Pradesh), and 153 females and 172 males at Hoskote and Whitefield near Bangalore (Mysore State). Two of the 38 *Heliothis* larvae collected from tomato fields at Hoskote ten days after liberation were found to be parasitised by this Tachinid. However, no recoveries were made later.

A nucleus culture of *Apanteles marginiventris* was also obtained from the U.S.A. in 1969. It parasitised *H. armigera*, *Chilo partellus* and *Spodoptera litura* in the laboratory. Some 135 adults were liberated at Whitefield. There is no indication that the parasite is established.

INDONESIA

It is stated (Anon, 1912) that satisfactory control of *H. armigera* was obtained following the importation of *Trichogramma pretiosum* from the U.S.A. into Sumatra in 1911. The parasite was found to be polyphagous, attacking over a dozen different species of Lepidoptera. Den Doop (1918) investigated its host range and spread in the field in Sumatra. Most of the females are small with weak ovipositors, so they are unable to reach *Heliothis* eggs on tobacco leaves. Further, the leaves are sticky and the eggs on them are, therefore, rarely attacked by the parasite. He found that damage to tobacco by *H. armigera* could be reduced by growing *Physalis angulata* Linn. and *Crotalaria striata* De around tobacco fields. If this is done before the tobacco is planted the moths lay eggs on these alternative host-plants in the absence of tobacco and being acceptable to *Trichogramma* these eggs are readily parasitised. Eggs of another insect, *Lampides boeticus* L. (Lep., Lycaenidae), on *C. striata* are also attacked by this parasite and thus help in building up its population in the field.

PHILIPPINES

Ecphoropsis perdistinctus (Viereck) (Hym., Ichneumonidae) was first obtained from the U.S.A. in 1953 for trial against *H. armigera* attacking tobacco but none of the 317 adults survived the journey. Adults emerging from another lot did not live long and no field releases were made (Baltazar, 1963).

(62) **Leguminous pod-borer**—*Maruca testulalis* (Geyer) (Lep., Pyralidae)

FIJI

M. testulalis is an important pest of leguminous crops. In 1967 and 1968 a total of 87 *Apanteles etiellae* Vier., 16,611 *Bracon cajani* Mues. and *B. thurberiphagae* (Mues.), 13 *Phanerotoma bennetti* Mues. (all Braconidae), 857 *Perisierola* sp. (Bethylidae) and 255 *Eiphosoma annulatum* Cresson (Ichneumonidae), which parasitise a related pod-borer, *Ancylostomia stercorea* (Zell.) in Trinidad, were introduced through the CIBC West Indian Station. It is not known whether they are established.

(63) **Nettle-grub**—*Thosea cervina* Moore (Lep., Limacodidae)

CEYLON

In 1932 a consignment of *Chaetexorista javana* was received from the U.S.A., where it was originally introduced from Japan and successfully established against the Oriental-moth *Cnidocampa flavescens* (Wlk.), and the parasites were liberated in fields where *T. cervina* was prevalent. It is not known whether the colonisation was successful (King, 1933; Clausen, 1956).

(64) **Oil-palm bagworm**—*Cremastopsyche pendula* Joannis (Lep., Psychidae)

MALAYSIA

In 1964 the CIBC Indian Station arranged to supply to Malaysia a culture of the virus on wattle bagworm, *Kotochalia junodi* (Heyl.), originating from South Africa. Preliminary laboratory experiments at the Chemara Research Station, Layang Layang, showed that the virus is pathogenic to *C. pendula*. However, it has not yet been tried in the field.

(65) **Giant African snail**—*Achatina fulica* Bowdich (Mollusca, Achatinidae)

The Giant African snail is widely distributed as a pest of various economic plants in several parts of South-East Asia, and attempts at biological control have been made in a number of areas. A detailed account of these attempts has been given by Mead (1961).

CEYLON

In 1957, 950 specimens of the predacious snail *Gonaxis quadrilateralis* (Preston) (Streptaxidae) from East Africa, and in 1958, 50 specimens of another predacious snail, *Euglandina* *rosea* Ferussac (Oleacinidae) (origin Florida) from Hawaii, were obtained for breeding and liberation against *A. fulica*. The numbers actually released are not known. Observations made in 1961–62 showed that *G. quadrilateralis* was well-established and multiplying in the laboratory gardens at Peradeniya (Adm. Reps., Dir. Agric. Ceylon, 1957, 1958 and 1961–62).

GUAM

The large musk-shrew *Suncus murinus* (L.) was first recorded on Guam in 1953, having been accidentally introduced there with cargo, probably from the Philippines. There were reports that the shrews were killing and eating *Achatina* but no evidence was found to substantiate this view.

Gonaxis kibweziensis Smith (origin East Africa) was introduced from Agiguan (Mariana Islands) in 1954 and 88 snails were released in the field. In 1955 another attempt was made to introduce this predator. Only a few *G. kibweziensis* were found in the original liberation site (R. Muniappan, pers. comm.). In 1958 *E. rosea* and in 1967 *G. quadrilateralis* were introduced. Only the former became established and it has now spread to many parts of the island and is giving some control of the pest (Dept. of Agri., Guam, News Release, 1971).

In 1955 the glow-worm *Lamprophorus tenebrosus* (Walker) was introduced from Ceylon and 933 larvae were released in four areas. There is no positive evidence of its having become established, though a few of the larvae survived for some time (Bess, 1956; Peterson, 1957 *a* and *b*).

HONG KONG

In 1968 shipments of *E. rosea* and *G. quadrilateralis* were sent by the CIBC West Indian Station to Hong Kong for release in the New Territories but the predators did not become established, possibly because the releases were made at an unfavourable time of the year.

INDIA

The CIBC Indian Station introduced *E. rosea* and *G. quadrilateralis*, the former from Bermuda in 1962 and the latter from Ceylon, East Africa, Hawaii and Trinidad in 1964–68. Both were bred in the laboratory and small liberations were made in the States of Assam, Kerala and Orissa. They were also sent to the Indian Agricultural Research Institute, New Delhi, which arranged for releases on the Andaman Islands. None has become established. The chances of establishment would be greater if releases are made at a more appropriate time of the year when the host is abundant.

INDONESIA

L. tenebrosus was introduced from Ceylon during 1954–55, but in the laboratory at Bogor all the 75 larvae received died within 3 months. The laboratory population was probably killed by mites which came in with the host snails. It was later believed that the predator larvae would have themselves been vulnerable to the ubiquitous chickens in all inhabited areas (Bess, 1956; Dresner, 1958).

MARIANA ISLANDS

During 1947 the Invertebrate Consultants Committee for the Pacific undertook a search for natural enemies of *A. fulica* in East Africa, and from the several enemies discovered

G. kibweziensis was selected for trial on some isolated islands. Agiguan, an island in the Marianas, was chosen, and about 300 *Gonaxis* were released in 1950. Mead (1961) remarks that the number of snails released has later been reported as 229 by Owen and as 407 by Davis. By 1951 the predator had become established and by 1952 it was exerting nearly 20% control over *Achatina*. Investigations in 1954 showed that *Gonaxis* had greatly increased in numbers and that the population of *Achatina* had undergone a drastic decline (Peterson, 1957 *b*).

MALAYSIA

A. fulica is a general pest of various crops such as vegetables, oil-palms, bananas, tobacco, etc. It was first recorded in Sabah (East Malaysia) in the 1930's and had presumably been introduced earlier from West Malaysia. It has now spread throughout the State. In 1962 and 1963 *E. rosea* was introduced from Bermuda (through CIBC West Indian Station) and released at Tuaran on the west coast. In 1964 *G. quadrilateralis* was imported from Hawai and released at Tawau on the east coast. In early 1968, further material of *G. quadrilateralis* was obtained from Trinidad and released at Tuaran. The predator has been breeding slowly at the release site at Tuaran. It seems to be confined to the release site, probably because of an abundant supply of *Achatina* in the area and the small number of predators (less than a hundred) originally released (CIBC unpublished records).

PHILIPPINES

In 1956 *G. kibweziensis* was introduced from Agiguan. Of the 58 snails received, 4 were dead on arrival. The rest were released at San Andres, Manila, but failed to become established.

In 1958 a consignment of 202 *E. rosea* (origin Florida) was received from Hawaii. These could not be bred and 85 snails that were left of the imported stock were released at four places. It is not known whether the predator became established (Baltazar, 1963).

(66) **Introduction of the Giant Toad—*Bufo marinus* (L.) against various pests**

FIJI

In 1936 *B. marinus*, a native of northern South America, was introduced from Hawaii to control slugs, beetles and millipedes. Jack (1936) and Simmonds (1937 *c*) reported its establishment in Fiji. The toad has generally helped in reducing the populations of such diverse pests as slugs, millipedes, *Spodoptera mauritia* and *Mythimna* (= *Cirphis*) *unipuncta* (Haw.) (Donald, 1939; Lever, 1939 *b* and *d*).

PHILIPPINES

B. marinus was introduced from Hawaii in 1934 primarily to control crickets, root-grubs and their adults, and many injurious moths. It was first reared in a large wire-cage at the Bureau of Plant Industry, Manila, and later liberated at Los Banos, Laguna, and several other places. The toad has become successfully established and can be found throughout the country. It feeds on many harmful insects but its value as a biological control agent has not been assessed. The stomach contents of several specimens caught in rice-fields were examined and found to consist mostly of insects (Baltazar, 1963). However, the toad is reported to kill chicks by biting them on the neck. It appears to have eliminated the native frog *Rana vittigera*, which is an equally good predator of insects. The toad showed a propensity to eat rice-grains and it also caused the death by poisoning of any animal eating it. Thus it is becoming a nuisance rather than an asset in the Philippines (Soriano, 1945).

SOLOMON ISLANDS

In 1940 *B. marinus* was introduced from Fiji into the British Solomon Islands, where it was reported to thrive on Guadalcanal and other islands (Lever, 1942 *c*). In 1945 when the stomach contents of the toads were examined, snails (*Subulina*), Pentatomid bugs, Elaterids, centipedes, caterpillars and earwigs were found (Lever, 1945 *b*).

TAIWAN

In 1935 the Giant toad was also introduced into Taiwan from Hawaii to control sugar-cane pests, but did not become established (Takano and Ijima, 1936; Takano, 1940).

(67) **Introduction of the praying Mantid**—*Tenodera angustipennis* Saussure

PHILIPPINES

The large praying Mantid *T. angustipennis*, introduced from Hawaii, was bred and liberated to control miscellaneous plant pests. The predator became established (Baltazar, 1963). Its value as a control agent has apparently not been assessed but it may be noted that praying Mantids and other general predators may kill a number of other beneficial insects.

Stored Grain Pests

(68) ***Alphitobius diaperinus* (Panz.), *Corcyra cephalonica* (Stnt.), *Cadra cautella* (Wlk.), *Tribolium castaneum* (Hbst.) and *Trogoderma granarium* Everts.**

Scarcely any attention has been paid to the biological control of pests of stored grain in the region. In India some preliminary experiments have been made. A Reduviid, ***Amphibolus venator*** (Klug.) found destroying the larvae of *T. granarium*, *T. castaneum* and *C. cephalonica* in grain stores in India was reared in the laboratory and tested for its effectiveness. In one test, 100 adults of *A. venator* were released in a warehouse containing 1,000 bags (100 tons) of wheat infested by *C. cautella* and *A. diaperinus*. This resulted in a decrease of the population of the former from 65·2 to 3·0 and of the latter from 212·5 to 23·5 per 25 sq. ft. in five months, while the populations of these pests in a warehouse kept free of the predator increased from 37·0 to 73·2 and from 174·0 to 281·2, respectively. The grain suffered much less damage in the warehouse containing the predator (Pingale, 1954).

De and Gopa Konar's (1956) experiments with *Bacillus thuringiensis* against stored grain pests gave insignificant results because *T. granarium* feeds within the grain and leaves most of the surface (which is treated) intact.

B. PESTS OF FOREST TREES

(69) **Balsam woolly aphids**—*Adelges* spp. (Hem., Adelgidae)

PAKISTAN

In 1966–67 some 1,850 *Neoleucopis atratula* Ratz. (Dip., Chamaemyiidae), 25,850 *Scymnus impexus* Muls. (Col., Coccinellidae) and 2,293 *Laricobius erichsonii* Rosenh. (Col., Derodontidae) were obtained by the CIBC Pakistan Station from the European Station and released on *Adelges*-infested firs in the Murree forests of West Pakistan. None of these predators was recovered.

(70) **Wood wasps**—*Sirex* spp. (Hym., Siricidae)

PAKISTAN

Adults of *Ibalia leucospoides* (Hoch.) (Hym., Ibaliidae) were obtained from the *Sirex* Biological Control Unit, U.K., in 1967–68. Some 200 adults were released in Siricid-infested areas in Swat and the Murree Hills (West Pakistan) but the species has not yet been recovered.

(71) **Teak-defoliators**—*Hapalia machaeralis* Wlk. (Lep., Pyralidae) and *Hyblaea puera* Cram. (Lep., Hyblaeidae)

INDIA, BURMA AND PAKISTAN

Several species of parasites of these forest pests have been exchanged between India and Burma and liberated in both countries but no attempts have been made to assess the results.

The Braconid *Cedria paradoxa* Wlkn. was the first parasite to be used to enhance natural control of teak-defoliators both in India and Burma. Although its normal host appears to be the mulberry defoliator, *Margaronia pyloalis* Wlk. in north India and China, it has been found to breed on a number of other species in the laboratory (Beeson, 1941), which has, of course, little bearing on its host preferences in the field. It has been bred regularly at the Forest Research Institute, Dehra Dun (Uttar Pradesh), and colonies have been sent to south India and Burma to control *H. machaeralis* and to the Punjab to control *M. pyloalis*. According to Beeson, in 1937 over 40,000 adults of *C. paradoxa* were released in 11 localities in teak-plantations at Nilambur (Kerala) and 15,000 in Changa Manga shisham—mulberry—plantations in the Punjab. In the same year, 40,000 were released in two lots in Madras State (now Tamil Nadu). It became established in Changa Manga.

In 1961 *C. paradoxa* was released in Daffar forest plantation by CIBC Pakistan Station and was subsequently recovered there.

A consignment was also sent to Burma, where 200,000 adults were bred and liberated in 170 localities during 1937–40. It was subsequently recovered from *H. machaeralis* and also from *Maruca testulalis* in two centres in 1938–39 but how far this introduction helped in the control of the pests is not known. Garthwaite (1940) also mentions its liberations and recoveries in Burma.

Trichogramma minutum (see foot note on page 22) was obtained from Mysore and 9,250 individuals were released in teak and mahogany plantations in 4 localities in Madras State.

The parasite developed in the eggs of *H. puera* but not in those of *H. machaeralis* (Beeson, 1938).

Beeson (1939, 1941) refers to the introduction into India of an unidentified *Trichogramma* sp. from Burma in 1937. It was reared on eggs of *H. machaeralis* and *Diacrisia obliqua* Wlk. (Lep., Arctiidae) and 227 adults were released in teak and mahogany plantations at Nilambur. He also refers to experiments conducted with *Trichogrammatoidea nana* to control teak-defoliators in Burma and Madras State (now Tamil Nadu). The "*Trichogramma*" referred to by him earlier is probably this species.

Beeson and Chatterjee (1939) and Beeson (1940) gave accounts of the methods employed in exchanging parasites between India and Burma. Those shipped in 1937–38 from Burma to Nilambur comprised *T. nana*, the Braconids *Apanteles malevolus* Wlkn. and *A. hyblaeae* Wlkn., and the Tachinids *Eucarcelia kockiana* Tns. and *Ptychomyia remota*. All except *A. hyblaeae* were liberated in the field. The parasites sent to Burma were: *Eriborus gardneri* Cush. (= *Dioctes gardneri* B. & C.) (Hym., Ichneumonidae) and *Goniozus montanus* Kieff. (Hym., Bethylidae) attacking *Hyblaea* and *C. paradoxa* attacking *H. machaeralis* and many other Lepidoptera in India. Garthwaite (1940) reports that these parasites were liberated in Burma to control *H. puera*. The first two species were not recovered, but initial recoveries of *C. paradoxa* were made. He also reports shipping *Tetrastichus* sp. and *Bracon* (*Cremnops*) *destructor* L., parasites of *Hapalia*, to India, where they were already present.

(72) **Toon shoot-borer**—*Hypsipyla robusta* Moore (Lep., Phycitidae)

INDIA

Beeson (1938) refers to the egg-parasite *Trichogramma minutum* (see foot note on page 22) being reared and released in mahogany plantations in Madras State, the nucleus culture having been originally obtained from Mysore. This parasite bred in the eggs of *H. robusta* on mahogany in the field.

(73) **Shisham defoliator**—*Plecoptera reflexa* Gn. (Lep., Noctuidae)

INDIA AND PAKISTAN

The indigenous *Microgaster plecopterae* Wlkn. (Hym., Braconidae) was bred and released in 1938–39 to control this important pest of young shisham (*Dalbergia sissoo* Roxb.) plantations in the Punjab (Beeson, 1941). At times, parasitism increased to as much as 60%, but whether this was a result of the liberations is not known. The same author refers to the shipment of *Eutachina civiloides* Baranov from Burma to Nilambur, apparently to control the shisham defoliator. Parasitism in nature by this Tachinid is reported to be low, not exceeding 4%, and the species was already known to occur in India.

In 1938 *Disophrys sissoo* Wlkn. (Braconidae), *Euplectrus parvulus* Ferriere (Eulophidae) and *E. civiloides* were liberated at Miranpur (Punjab). In addition, the Carabids *Anthia sexguttata* F. and *Calosoma maderae indicum* Hope were also reared at Miranpur. In 1939 *D. sissoo*, *E. parvulus*, *Meteorus dichomeridis* Wlkn. (Braconidae) and *Podomyia setosa* Dol. (Dip., Tachinidae) were liberated at Miranpur and *M. plecopterae* at Miranpur, Arafwala and Diplapur. A few recoveries of *D. sissoo*, *E. parvulus* and *P. setosa* were made later from host larvae collected at the liberation sites, and two cocoons of *M. plecopterae* were recovered at Miranpur (Beeson, 1940; Mathur, 1942).

C. BIOLOGICAL CONTROL OF LAC PREDATORS

(74) *Eublemma amabilis* Moore (Lep., Noctuidae) and *Holcocera pulverea* Meyr. (Lep. Tineidae)

INDIA

Larvae of *E. amabilis* and *H. pulverea* feed on the lac-insect *Kerria lacca* and cause severe loss to lac production. Attempts have been made in India to control these predators by using the native parasites *Bracon* (*Microbracon*) *greeni* and *Apanteles tachardiae* Cam. and also *Bracon* (*Microbracon*) *hebetor* obtained from Ceylon. Mass-breeding and weekly releases of *B. greeni* caused a reduction in the population of *E. amabilis* in three of the four lac crops during 1944–45. Therefore releases were continued later. Efforts were also made to breed *Elasmus claripennis* Cam. (Hym., Elasmidae) on *Eublemma*, and *A. tachardiae*, *Apanteles fakhrulhajiae* Mahdn. and *Perisierola pulveriae* Kurian on *Holcocera*. Only *A. tachardiae* could be bred and several thousands were released during 1957–58 and 1961–62. The results of these releases are not known (Ann. Reps. Indian Lac Res. Inst., 1944–45, 1955–58, 1961–62).

D. PESTS OF MEDICAL AND VETERINARY IMPORTANCE

(75) Cockroaches

COOK ISLANDS

In 1955 *Ampulex compressa* (F.) (Hym., Ampulicidae) was imported from Hawaii. Twenty-three adults and 275 cockroaches parasitised by *Ampulex* were liberated. The parasite is established in Rarotonga but its effectiveness has not been assessed (unpublished report, Dept. of Agriculture, Cook Islands).

FIJI

Cockroaches parasitised by *A. compressa* were imported from Hawaii in 1935 but breeding of the parasite was unsuccessful (O'Connor, 1960 *b*).

GUAM

Peterson (1956 *c*) mentions the introduction from Hawaii in 1953 and 1954 of *A. compressa* to control *Periplaneta americana* (L.) (Dictioptera, Blattidae) but whether it is estab lished is not known.

(76) Houseflies—*Musca* spp. (Dip., Muscidae)

FIJI, SAMOA AND SOLOMON ISLANDS

In Fiji the housefly *Musca domestica* L. attained plague proportions and was blamed for a serious outbreak of dysentery, including the more dangerous variety caused by the 'shiga' bacillus present in the intestines of houseflies (Simmonds, 1958). Wound-infections and an eye-disease which could lead to blindness were also attributed to this pest.

In 1929 *Spalangia cameroni* Perkins (Hym., Pteromalidae) was introduced into Fiji from Hawaii and released at four localities (Simmonds, 1929 *d* and *e*). Lever (1934) mentioned the introduction into the Solomon Islands of *S. cameroni* from Fiji and its liberation on Guadalcanal, and doubted its effectiveness against the local housefly *Musca domestica vicina* Macq. Since the flies bred in cattle droppings on pastures, the dung-beetle *Copris incertus* var. *prociduus* Say (Col., Scarabaeidae) was introduced from Hawaii and 615 were liberated near Suva. Although it became established and was observed to destroy 50% of the housefly puparia in the field, the overall control of the fly population was unsatisfactory. A predacious Muscid fly, *Mesembrina meridiana* (L.) from the United Kingdom was also introduced in 1931 but did not become established. An African parasite of housefly puparia, *Dirhinus* sp., was imported in 1936. It bred freely in puparia of houseflies and Sarcophagids in the laboratory and was liberated in large numbers. Its value in controlling the housefly was doubtful (Simmonds, 1940 *b*). In 1938 another predator, *Pachylister chinensis*, was introduced from Indonesia (Java). The predator was recovered 15 months after liberation (Simmonds, 1940 *a*, 1958). Simmonds (1940 *a*) also mentions the shipment of *P. chinensis* to Samoa and the Solomon Islands where it became established. It was also released in the Palaus in 1952 but did not become established. By the late 1940's houseflies had become reduced in Fiji and by the early 1950's it was claimed that this beetle had brought the housefly under control. Bornemissza (1968) investigated the present status of *P. chinensis* in Fiji and was convinced that the reduction of housefly numbers in Fiji during the post-war years cannot be attributed to the activity of *P. chinensis*. It is more likely that it was achieved by the widespread use of potent insecticides, combined with a higher standard of hygiene.

GUAM

S. cameroni was introduced from Hawaii in 1928. It became well-established there but became rather scarce by 1940 (Swezey, 1940). *C. incertus* var. *prociduus* was also introduced. from Hawaii against *Musca domestica*, *M. sorbens* Wd. and other flies. In 1958, Gardner reported that it was too early to evaluate the effectiveness of the insect. Apparently no recent assessment has as yet been made.

(77) Mosquitoes

Use of predacious mosquitoes

FIJI

Larvae of all known species of the genus *Toxorhynchites* (= *Megarhinus*) are predacious on those of other mosquitoes. The genus is widely distributed in the tropics but was not known from the Pacific Islands before 1929. In 1931 *Toxorhynchites splendens* (Wied.) was introduced from Indonesia (Java) against *Aedes scutellaris* (Walker)—group, which is responsible for the spread of human, and possibly, canine filariasis. Within six months 14 colonies were liberated at six sites and the insect was recovered towards the end of 1931. By 1932 altogether 51 colonies were liberated and *T. splendens* became definitely established.

On the island of Taveuni it caused 20% reduction in the number of *Aedes*-infested tree holes. In 1933 *T. inornatus* (Wlk.) was also introduced from New Britain, bred and liberated (Paine, 1934 *b*).

GUAM

Peterson (1956 *c*) and Gardner (1958) refer to the introduction of non-blood-sucking predacious mosquitoes *Toxorhynchites brevipalpis* (Theob.) and *T. splendens* from Hawaii to control *Aedes albopictus* Skuse and *A. pandani* (Stone). In both cases establishment is doubtful.

Use of larvivorous fishes

A great deal of attention has been paid to the biological control potentialities of mosquito-eating fish. Perhaps the first long-distance transportation of *Gambusia affinis* (Baird and Girard) from its native southern U.S.A. to this region commenced at the turn of the century.

CEYLON

Carter *et al.* (1927) mention the successful establishment of the imported guppy, *Lebistes reticulatus* (Peters), a native of northern South America.

COOK ISLANDS

In 1932 a private individual introduced *Gambusia* into Rarotonga. Subsequently the Agriculture and Health Departments collaborated in introducing the fish on a large scale. In 1950 the Agriculture Department introduced *Tilapia mossambica* Peters for mosquito control. However, no evaluation of these fishes in the control of mosquitoes has been made (D. Peyroux, Acting Director of Health, pers. com.).

FIJI

Jack (1935) mentioned Jepson's introduction of *Gambusia* from Hawaii in 1910 and that it proved a useful predator of mosquito larvae.

HONG KONG

Gambusia was first introduced into Hong Kong by aquarium dealers, primarily as food for the larger aquarium cichlids. However, a few individuals that escaped have very efficiently established themselves in natural freshwater systems and particularly in fish-farms in Hong Kong. Despite the large population of these fishes, mosquitoes are still plentiful in the areas where these fishes occur. To the fish-farmers, *Gambusia* species are more of a pest, as they are capable of multiplying at an extremely high rate (W. L. Chan, Dept. of Agriculture and Fisheries, pers. com.). However, in the New Territories where these fishes live in small areas of stagnant or slow-running shallow water, usually very few or no mosquito larvae are found (G. W. Chau of the Urban Council and Urban Services Department, pers. com.).

L. reticulatus was also introduced from the New World as a popular aquarium fish, of which many varieties are being bred. It has not become established in wild habitats.

INDIA

From the beginning of this century reports began to appear of the larvivorous habits of various Indian fishes. Detailed investigations on certain species have been made concerning the importance of mosquito larvae in the diet of fishes occurring in diverse natural habitats and experimental waters, the extent of control exercised by the fish in different types of water, the effect in the field of introducing and of withdrawing the fish, the comparative efficacy as well as relative costs of biological and chemical measures, the life-history and bionomics of some of the species of proved utility, etc. The practical utility of a number of species has been established beyond doubt and this has been discussed by Hora and Mukerji (1953).

In 1909 an unsuccessful effort was made to acclimatise the guppy (O'Donnell, 1930). Later it was introduced more than once and is now found in restricted areas in south India. It occurs both in fresh and brackish waters. Kalra *et al.* (1967) found this species in a canal at Nagpur carrying sullage water and that this particular tract was free of *Culex pipiens fatigans* Wied., a vector of filariasis. But for this fish this canal would have been an ideal breeding place for mosquitoes, which suggests the feasibility of utilising *L. reticulatus* to control *C. p. fatigans*.

Carassius auratus (L.), the famous 'gold-fish' which has been carried from the Far East to all parts of the world as an ornamental species, is an effective mosquito destroyer. In ornamental ponds this fish can be used with great advantage but it is uneconomical to introduce the species on a large scale. The trade varieties of this fish are very different from the natural form which is only available in its native home (Hora and Mukerji, 1953).

The top-minnow, *Gambusia affinis*, has been extensively used in different parts of the world. It was established after introduction into India in 1928 when a consignment was brought from Italy by Dr. B. A. Rao of the Mysore State Health Department (Covell, 1962). It was sent to the Karnal (Punjab) Experimental Station for Malaria in 1929 and later supplied to many other parts of India. Mulligan and Majid (1936) considered this fish to be capable of adapting to climatic conditions prevailing in all parts of India where it has been tried and it seems likely that it will prove capable of surviving in many parts of this country where malaria is a problem. However, Hora and Mukerji (1953) referred to the damage that *Gambusia* might do to carp culture and to other food fishes in their young stages and cautioned that this should be specially looked into before it is propagated in this country.

INDONESIA

No information is available as to when *Gambusia* and *Lebistes* were introduced but these are present in Indonesia. However, these fishes have not been used to control mosquitoes (M. P. H. Soemarlan, National Research Institute of Health, Djakarta, pers. com.).

IRAN

Gambusia affinis holbrocki (G.) was introduced from Italy into the northern provinces during 1922–30. The fish reproduced and became well-established in the Ghazian marshes on the Caspian Littoral. In 1966 it was transported to and distributed in southern Iran to aid in the control of *Anopheles stephensi* Liston, *A. fluviatilis* James, *A. superpictus* Grassi and *A. d'thali* Patton. Over 3,000 permanent water tanks in the south have been stocked with *Gambusia* and in 1969 over 1½ million fish were distributed. In general *Gambusia* has helped in the malaria eradication programme in Iran, but since its introduction has only been a part of a larger programme, including residual spraying and other measures, it has not been possible to evaluate on a large scale the effectiveness of any one measure [from unpublished WHO document WHO/VBC/70.198 (WHO/Mal/70.716)].

MALAYSIA

According to Mr. Zainuddin bin Abdul Bahari of the Ministry of Health, Kuala Lumpur (pers. com.), *Gambusia* and *Lebistes* are present in Malaysia. When these were imported is not known but he believes that this may have been from a neighbouring country such as India, probably in the early part of this century. *Gambusia* is found mainly in ponds and *Lebistes* in man-made ditches and drains all over the country. Dr. R. M. Melville, Director of Medical Services, Sarawak, has stated (pers. com.) that *Gambusia punctata* was introduced into Sarawak in 1967, but how useful the introduction has been is not known.

Gambusia, though present in Sabah, has not been introduced as a biological control agent against mosquitoes because the main vector of malaria breeds in small temporary or semi-permanent collections of water in forests where this fish would not be able to thrive. *L. reticulatus*, which is found breeding in small streams near town areas, seems to tolerate high degrees of pollution. In some habitats they do control mosquitoes to some extent (N. K. Rajapaksa, Medical Entomologist, Sabah, pers. com.).

PHILIPPINES

In 1913 *G. affinis* was introduced from Hawaii, where it was colonised in 1905 from a stock obtained from the U.S.A. The fish was bred and released in streams and swamps in the Philippines. It was able to multiply in natural habitats (Seale, 1917).

THAILAND

In Bangkok *L. reticulatus*, which had been introduced by an unknown agency and found breeding in a sewage pool in 1961, was transferred to a large number of similar pools to control *C. p. fatigans*. It became established in many parts of the city and proved to be the most effective agent for controlling this mosquito (Sasa *et al.*, 1965).

VIETNAM

G. affinis, though present, has not so far been used for mosquito control. However, *Tilapia natalensis* (imported from Indonesia in 1958), *Helostoma temminokii* (imported from Hong Kong in 1959), *Ctenopharyngodon idella* Val. (imported in 1965, source not specified) and *Cyprinus carpio* L. (imported from Indonesia in 1955) are known to feed on mosquito larvae. However, their usefulness in killing mosquito larvae has not been investigated (Nghiem-Bao Thang, Administrator, National Malaria Programme, pers. com.).

(78) **Rats**

Damage to crops and stored grains by rats is well-known. The ectoparasites of rats are equally important on account of their ability to transmit dangerous diseases to man, notably human plague and murine typhus which are transmitted by rat fleas. Very little has been done to control rats by biological methods.

INDIA

Buchanan (1908 and 1910) cited the absence of plague from villages in India where cats were abundant. However, attempts to exploit domestic cats on a meaningful scale have often been disappointing (Laird, 1966).

FIJI

The Indian mongoose, *Herpestes auropunctatus auropunctatus* Hodg., was deliberately introduced from Jamaica (Lewis, 1942) into various Fijian Islands, in the expectation of reducing rat populations, particularly in sugarcane fields. It proved to be undesirable by eating fruit and attacking poultry and other birds (Laird, 1966).

((79) **Buffalo-fly**—*Lyperosia Siphona*) *exigua* (de Meij.) and **horn-fly**—*L. irritans* (L.) (Dip., Muscidae)

GUAM

The Scarabaeids *Copris incertus prociduus* and *Onthophagus incensus* Say were introduced from Hawaii in 1953 to control *L. irritans*. While the former is believed to be established there is no evidence of establishment of the latter (Peterson, 1956 *c*).

SOLOMON ISLANDS

L. exigua is believed to have reached the British Solomon Islands *via* New Britain prior to 1923. In 1933 an attempt was made to exercise some control by liberating a small colony of *Spalangia cameroni* introduced from Fiji. As this parasite was known to have a wide range of hosts, it was decided to introduce the more specific *Spalangia sundaica* Graham from Australia, where it had been introduced in 1933 from the East Indies. Some 2,500 parasitised pupae were sent to Solomon Islands from Brisbane and the parasite was released in 1936 on Guadalcanal near the stock-yards of a coconut plantation. The result of this liberation is not known (Lever, 1937).

The Histerid beetle *Pachylister chinensis* was introduced from Fiji and released in 1939. It became established (Bornemissza, 1968).

(80) **False black-widow spider**—*Latrodectrus geometricus* (Koch.)

TRUST TERRITORY

This poisonous spider occurs on several islands in the Territory. It was found to be abundant in residential buildings on Kwajalein and in 1950 a Eurytomid wasp, *Eurytoma latrodecti* (Full.), was introduced from Hawaii and released. It became established (Gardner, 1958) but it is not known whether this wasp has controlled the spider to any extent.

(*a*) Terrestrial Weeds

(1) **Prickly pears**—*Opuntia* spp. (Cactaceae)

INDIA AND CEYLON

The first cactus insect introduced into India was *Dactylopius ceylonicus* Green (= *indicus* Green) (Hem., Coccidae), which was apparently mistaken for the true cochineal and introduced from Brazil (*see* Green, 1922) about 1795 or earlier for commercial production of cochineal dye. Its propagation on *Opuntia vulgaris* Mill. was started in the Calcutta Botanical Garden and at Madras, but was unsuccessful as a commercial proposition since it was much inferior to *D. coccus* Costa in dye production. However, in the field it spread rapidly on the wild *O. vulgaris* and by the middle of the 19th century had become widespread in north and central India. About this period it was introduced into Ceylon from Madras and established on *O. vulgaris*, which was soon brought under control. In the latter half of the 19th century attempts to distribute *D. ceylonicus* against *Opuntia dillenii* (Ker–Gawl) Haw. and *O. elatior* Mill. in south India were not successful, since it would not feed on them. However, it effectively controlled *O. vulgaris* in north India and practically exterminated this species in the south (Ramakrishna Ayyar, 1931; Beeson, 1941).

The North American species *D. opuntiae* (= *tomentosus* Lamarck) was introduced into south India in 1926 from Ceylon where it had been imported in 1924 from Australia and gave very good control of *O. dillenii* (Hutson, 1926, 1928). It spread rapidly all over peninsular India, attacking *O. dillenii* and *O. elatior*, and by 1930 it had become established over an area of about 40,000 sq. miles. By 1933 it had even reached as far north as Delhi (Beeson, 1941). The introduction of this insect in Mewar (Rajasthan) and the effective control of prickly pear there have been described by Dass (1934). Deshpande (1935) described how, between 1931 and 1934, it was propagated over large areas in the former Bombay Presidency. David and Muthukrishnan (1953) found this species attacking the spineless cactus *Nopalea cochenillifera* (L.) Salm-Dyck which can therefore serve as an alternative food plant.

INDONESIA

To control *O. elatior* which severely infested abandoned rice-fields and pastures in the Palu Valley, North Celebes, a consignment of *D. opuntiae* was obtained from Australia in 1934. It was bred on *O. elatior* in a greenhouse at Buitenzorg. It was also bred on *N. cochenillifera*, a cactus sparsely distributed throughout Indonesia, but did not survive on *O. vulgaris*. In 1935 infested material was distributed in Palu. Wherever *D. opuntiae* was liberated, it spread rapidly on *O. elatior*. By 1936 many plants were dying, and by the end of 1939 cactus had disappeared from the valley, giving place to new growth of *Leucaena glauca* Benth. and other plants (van der Goot, 1940).

NEW CALEDONIA

Cactoblastis cactorum Berg. (Lep., Phycitidae) (origin Argentina) was introduced from Queensland in 1933 to control *O. dillenii*, which constituted a danger to the island. It readily attacked this weed but not *O. tomentosa* Salm-Dyck to the same extent. Within a year it became well-established in one locality (Jacques, 1933).

Dactylopius sp. near *confusus* (Ckll.) (origin Argentina) was bred in the laboratory and liberated in the field. Very good control was achieved (Szent-Ivany, 1964).

(2) ***Lantana***—*Lantana camara* L. (Verbenaceae)

COOK ISLANDS

The leaf-mining Hispid *Uroplata girardi* Pic. (origin South America) was introduced from Fiji in 1969. The beetle is doing considerable damage to *Lantana* bushes in some of the areas but it is too early to evaluate the results (Simmonds, 1971).

FIJI

In 1911 Jepson introduced *Ophiomyia lantanae* (Frogg.) (Dip., Agromyzidae) (origin Mexico) from Hawaii to control *Lantana*. It became so thoroughly established that it was not possible to find the weed within several miles of Suva. A small Chalcid parasite attacked this Agromyzid but not in sufficient numbers seriously to affect its spread (Jepson, 1916; O'Connor, 1950 *b*).

In 1922–23 the flower-feeding butterflies *Thecla bazochii* (Godart) and *T. echion* (L.) (origin Central America) were obtained from Hawaii and liberated. The former became well-established in Fiji while the latter failed to do so (Simmonds, 1934; O'Connor, 1950 *b*).

In 1928 between 10,000 and 12,000 adults of the Tingid bug *Teleonemia scrupulosa* Stal (origin Mexico) were collected from two different localities in Hawaii and introduced into Fiji. Some 4,050 adults were liberated in the Suva District. At the end of 1928 a colony of 2,000 adults and nymphs of *T. scrupulosa* was liberated in Taveuni. The bug became well-established at liberation sites near Suva and caused yellowing and loss of foliage of *Lantana*, also preventing flower-production and seed-set over considerable areas. The incidence of *T. scrupulosa* in Fiji was adversely affected by wet weather, and it almost disappeared from some areas where it previously showed promise of being of value, but the predacious Lygaeid *Germalus pacificus* Kirk. was probably the most important factor in holding it in check.

Of the four insects introduced into Fiji from Hawaii *O. lantanae*, which destroys the pericarp of the seeds, *T. bazochii* which attacks the flower-buds and *T. scrupulosa* have become well-established, but the last is only effective in dry weather (Simmonds, 1929 *a*, *b*, *c*, 1930, 1932 *a* and *b*, 1934).

In 1952 Fiji joined with Australia and Hawaii in a project to import additional insects against the weed and several were introduced into Hawaii from Mexico. The first to be subsequently released in Fiji in 1954 were the moths *Blepharomastix acutangulalis* (Sn.) (Pyralidae) (600 adults and 2,000 larvae) and *Diastema tigris* Gn. (Noctuidae) (in small numbers), the larvae of which feed on leaves (Parham *et al.*, 1956). Neither of these became established. In 1956, 25 adults of *Aerenicopsis championi* Bates (Col., Cerambycidae) and 38 adults of *Octotoma scabripennis* Guerin (Col., Hispidae) were imported but not released (O'Connor, 1956, 1960 *b*).

In 1958 and 1959 *Syngamia haemorrhoidalis* Guen. (Pyralidae) (origin Central America) was introduced from Hawaii. It was bred in the laboratory and about 1,200 moths were liberated over a period of 18 months. It became established on Viti Levu but without showing any marked effect on *L. camara*. About 665 moths in seven lots were also sent to Taveuni and Vanua Levu. In 1960 *Hypena strigata* (F.) (origin East Africa) was imported from Hawaii, bred and liberated on Viti Levu, Taveuni and Vanua Levu (O'Connor, 1960 *b*, 1964). This has also become established but since none of the introduced *Lantana* insects has proved very effective importation of other species is under consideration (Simmonds, 1971).

INDIA

L. camara is one of the most important exotic weeds in India. It is believed to have been introduced about 1809 and planted in the Calcutta Botanical Garden as an ornamental plant and subsequently in other places for the same purpose. It then spread rapidly and became a serious weed. An extensive survey of insects feeding on *L. camara* carried out by Ramachandra Rao (1920) indicated about 150 species feeding on the leaves, flowers and fruit. The seed fly *O. lantanae* (of Mexican origin) was not found during the survey. As reported by Subramanyam (1934), 273 adults of this fly, from material imported from Hawaii, were liberated in Bangalore in 1921 under extremely unfavourable climatic conditions. No trace of attack on *L. camara* berries at the release site was noticed for many years, but in 1933 it was unexpectedly found in the fruits of *L. camara* in Bangalore. Further samples from widely separated localities in Mysore State had 2 to 5% infested berries, while from others obtained from Travancore, Saharanpur and Bombay (also from Burma), large numbers of the flies emerged. It was considered by Subramanyam that the Agromyzid had perhaps been present in India for a long time and that the progeny of the small number of flies liberated could not have spread so extensively, although the lack of recoveries at Bangalore during 1921–32 is difficult to explain. (A rather similar series of events also occurred in East Africa. *O. lantanae* was introduced but was soon found in so many widely separated areas that it appeared as if it must have been present prior to the introductions.) The Forest Research Institute, Dehra Dun, carried out studies during 1937–38 on insects attacking *Lantana*. Beeson (1939) reported that *O. lantanae* attacked the fruits but did not affect the germination of the seeds. However, Beeson later (1940, 1941) stated that the high biotic potential of the fly and the upper air currents were sufficient to account for its rapid dispersal. Beeson and Chatterjee (1940) suggested the introduction of the lace bug *T. scrupulosa* (= *lantanae* Dist.) (origin Mexico). Beeson (1941) stated that *T. scrupulosa* may flourish in one or more of the climatic regions of India and cause wholesale destruction of *Lantana* where the shrub is dense and extensive enough to keep up an accessible sequence of flowers and new shoots during the first epidemic period after colonisation. *T. scrupulosa* was introduced in 1941 (Roonwal, 1952) from Australia and tests were carried out at Dehra Dun to determine its value against *Lantana* in India and to see whether there was any risk of attack on economic plants, notably teak which belongs to the same family (Verbenaceae). After three years it was shown that (i) the bugs preferred *L. camara*, and especially its flowers, to any other plants offered; (ii) they migrated to teak leaves only after *L. camara* was defoliated; (iii) they did not cause appreciable injury to the teak leaves, but might do so to the flowers; and (iv) they tended to ascend the teak trees, eventually reaching the flowers to feed on them. It was, therefore, considered inadvisable to liberate the bug unless future tests should prove that teak flower would not be seriously affected (Gardner, 1944; Khan, 1945). The laboratory stocks were destroyed in 1943. However, the bug was found on *L. camara* near Dehra Dun in 1951. Further investigations showed that the Tingid was established in several places in the area, as far away as 26 miles from the laboratory and it was concluded that some had escaped. However, there was no sign of infestation on teak in the area (Roonwal, 1952).

Recently, Joshi (1969) reported that *T. scrupulosa* attacks and kills *L. camara* on a fairly large scale in the neighbourhood of Bhimtal, Nainital District (Uttar Pradesh). He also stated that the bug did not attack a number of agricultural and fruit crops and forest trees that were offered to it, even in the absence of *Lantana*.

In 1968–69 *S. haemorrhoidalis*, *D. tigris* and *Uroplata girardi* were obtained from the CIBC, West Indian Station. Field releases have not yet been made.

INDONESIA

T. scrupulosa was imported from Australia in 1939. The culture was destroyed in 1940 but some bugs had escaped from the laboratory in Bogor and within ten years the bug had spread all over Java, the Lesser Sunda Islands and Celebes. In 1954 it was deliberately introduced into Timor although it had also been feared that it might prove injurious to teak. The bugs appeared useless for the control of *Lantana*, since they were washed away in the wet monsoon period and the infested bushes grew again (Van der Vecht, 1953; Djojopranoto, 1957). However, Dresner (1958) reported that it became established in Timor and many other areas within a year.

MALAYSIA

T. scrupulosa has been found attacking *L. camara* at Tuaran (Sabah). It is likely that this Tingid has spread here naturally from some other area (? Indonesia) where it was introduced to control *Lantana* (CIBC unpublished records).

NEW CALEDONIA

O. lantanae was introduced from Hawaii and became well-established and spread rapidly (Perkins and Swezey, 1924). Later *T. scrupulosa* was introduced from Fiji (Lever, 1938 *d*). These two insects are limiting the spread of *Lantana*. Attempts were made to introduce *S. haemorrhoidalis* from Hawaii but all pupae and adults died *en route* (Szent-Ivany, 1964).

TRUST TERRITORY

L. camara is a troublesome weed on Ponape in the Eastern Carolines, particularly in areas where coconuts are cultivated. In 1948 and 1949 *T. scrupulosa*, *Epinotia lantanae* (Busck) (Lep., Tortricidae) (origin Mexico), *O. lantanae* and *Platyptilia pusillidactyla* (Wlk.) (Lep., Pterophoridae) were introduced from Hawaii and released. The first two species have become established and are exerting some control (Gardner, 1958).

(3) **Koster's Curse**—*Clidemia hirta* (L.) D. Don (Melastomaceae)

FIJI

C. hirta, which is of West Indian origin, was accidentally introduced into Fiji and became a serious pest. *Liothrips urichi* Karny occurring in Trinidad was reported to be of possible value as a biocontrol agent, and hence feeding tests were carried out there with a view to its introduction into Fiji (Kermack, 1928). In 1930 a consignment of approximately 20,000 *L. urichi* was shipped to Fiji. The thrips became established and spread in Fiji. However, probably owing to the exceptionally dry weather towards the end of 1930, the thrips had made very little progress by February 1931. Later in the year, however, it spread rapidly. It was assisted by the cutting down of heavy growth of *C. hirta*, since the new shoots that appeared favoured its rapid multiplication. These results were in general most encouraging. When attacked by the thrips the weed became stunted and was soon eliminated by competition with other rapidly growing plants. *L. urichi* has certainly brought *C. hirta* under control over large areas, not by directly killing it, but by so inhibiting growth that it was no longer able to compete with dominant local plants. In Trinidad, the thrips showed a marked aversion for shade, but in Fiji, probably owing to the much denser thrips population resulting from an absence of natural enemies, it penetrated into the jungle and heavily colonised clumps of the weed receiving even a moderate amount of light. The insect has little effect in very wet areas under dense shade or in areas where grazing is intense, because the competing vegetation is unable to suppress the weed (Simmonds, 1930, 1932 *c*, 1933 *b* and 1934).

Fyfe (1936) reported that, following the introduction of the thrips, in one locality where previously the weed had to be cut every six months, cutting was required only once in two years and even then only in areas where grazing had been very heavy. He further reported that weeding costs had been reduced by 75%. According to Paine (1934 *a*) and Simmonds (1937 *b*) a fluctuating balance had been established over most of the infested area, the thrips population being maintained on isolated bushes.

SOLOMON ISLANDS

Although *C. hirta* is believed to have been present in the British Solomon Islands since about 1929, it was not reported until 1936. In 1938 an unsuccessful attempt was made to import *L. urichi* from Fiji (Lever, 1938 *a* and *c*).

(4) **Dodder**—*Cuscuta* spp. (Convolvulaceae)

PAKISTAN

Smicronyx cuscutae Mshl. (Col., Curculionidae) naturally occurring in West Pakistan was released (1,000 adults) on *Cuscuta* infestations in Dacca (East Pakistan) in 1968 by the CIBC, Pakistan Station. It became established initially, but as soon as the *Cuscuta* infestations diminished, the insect population declined and eventually disappeared. So far there is no indication of its having dispersed to surrounding areas, or that it is established.

(5) **Tobacco weed**—*Elephantopus mollis* (Kuntl.) (Compositae)

FIJI

A seed-fly, *Tetraeuaresta obscuriventris* (Lw.), was shipped to Fiji from Trinidad by the CIBC, West Indian Station in 1957. About 7,000 adult flies were liberated in the field and the species quickly became established, occurring in vast numbers throughout the main island of

Viti Levu. However, no quantitative assessment has been made to determine the extent of control, if any, exerted by the seed-fly (O'Connor, 1960 *b*; Simmonds, 1967).

(6) **Crofton weed**—*Eupatorium adenophorum* Spreng. (Syn. *Eupatorium glandulosum* HB & K.) (Compositae)

INDIA

In 1963 shipments of adults of *Procecidochares utilis* (Stone) (Dip., Cecidomyiidae) (originating from Mexico) and galls infested by it were imported from New Zealand by the CIBC Indian Station for trial against *E. adenophorum* which occurs on hill slopes in the Nilgiris and Palni hills and in parts of Assam, West Bengal and Uttar Pradesh. Trials in the laboratory at Bangalore showed, as already found in Hawaii, Australia and New Zealand, that the fly is highly host-specific and does not even attack the allied *E. odoratum*. *P. utilis* was bred successfully in the laboratory, both at Bangalore and at Kalimpong (West Bengal). It was liberated at Ootacamund (Nilgiris) and in different localities in West Bengal. It is now widespread in the Nilgiris and at Darjeeling and is giving control of the weed in some areas. The native parasites *Dimeromicrus kiesenwetteri* (Meyr.) (Torymidae) and *Syntomopus* sp. (Pteromalidae) have been recorded attacking the gall fly. Most recent indications are, however, that its value as a biocontrol agent in these areas is very limited—possibly because of the action of parasites. Whilst die-back of the weed has occurred in some drier areas—where *Eupatorium* is in fact only marginally established, in the wetter and particularly in shaded areas, where growth of the weed is more vigorous, little control has been achieved to date, even though galls may be very numerous on the plants. It remains to be seen if there will be any long-term effects as a result of any possible weakening of the plants due to gall-formation.

(7) **Noogoora Burr**—*Xanthium strumarium* L. (Compositae)

FIJI

As Noogoora fruits throughout the year in Fiji, it was thought that it might be more effectively controlled by the seed-destroying *Euaresta aequalis* (Lw.) (Dip., Tephritidae) (originally introduced from the U.S.A.) than in Queensland where fruits are produced only seasonally. Adults, puparia and larvae in diapause were collected in Queensland and taken to Fiji in 1951, where more than 2,000 adults (some mated) were liberated. It was reported later that it had not been recovered (O'Connor, 1952, 1960 *b*).

(*b*) Aquatic weeds

The possibilities of biological control of aquatic weeds in the piscicultural waters of South-East Asia have been discussed by Philipose (1966).

The grass-carp *Ctenopharyngodon idella*, a native of China, has been successfully introduced into many parts of South-East Asia and reported to be the most effective fish in controlling certain types of aquatic vegetation. In India, Alikunhi and Sukumaran (1964) found that this fish consumed *Hydrilla*, *Nechamandra* (*Lagarosiphon*), *Azolla* and *Lemna*. Ponds choked with *Hydrilla* have been cleared within a month by stocking with 300–375 grass-carp (weighing 78·8 to 173 kg.) per hectare. The age and size of the fish are important in determining the type of weeds attacked and extent of control. Other acquatic weeds which have been controlled by the grass-carp in field trials carried out in India are *Najas*, *Ceratophyllum*, *Wolffia*, *Spirodela*, *Ottelia*, *Vallisneria*, *Utricularia*, *Trapa*, *Myriophyllum*, *Limnophila* and *Salvinia* (Singh *et al.*, 1967). In Pakistan efforts are being made to assess the suitability of the grass-carp in controlling weeds in reservoirs (Philipose, 1966). The grass-carp was introduced into Hong Kong many years ago for the purpose of fish-farming and not for weed control. Here fish-farmers actually ensure that adequate supplies of aquatic weeds are maintained in ponds to feed the fish (W. L. Chan, pers. com.).

Hickling (1962) mentions that in Malaccan ponds the grass-carp and another herbivorous fish, *Puntius javanicus* (Bleeker), effectively control *Enhydrias angustipetala* and *Chara*. In Indonesia, the grass-carp was first introduced in 1964 to control weeds in lakes and reservoirs but all the fish died. It was reintroduced later and bred in experimental ponds at Bogor (M. P. H. Soemarlan, pers. com.). The practical results of this introduction are not known.

Several species of *Tilapia* are herbivorous. In the Indonesian brackish-water ponds, *Tilapia mossambica* has helped in the elimination of filamentous algae. This species has been successfully used in clearing large patches of *Potamogeton crispus* and *Utricularia* sp. in the Fena Reservoir on Guam. In India ponds intensively stocked with this fish have generally been free of soft submerged vegetation and filamentous algae. In Malacca *Tilapia zillii* has been found to be more effective than *T. melanopleura* Dumeril in controlling *Fimbristylis* (Philipose, 1966). *P. javanicus* and *T. zillii* are being used to control aquatic weeds in fish ponds and lakes in Sarawak (East Malaysia) (R. M. Melville, pers. com.).

Tilapia is reported to be not so effective as the grass-carp or *Puntius*. The former is not a good pond fish because of its habit of frequent reproduction which results in over-population and a consequent reduction in the size of individuals (Philipose, 1966).

PART II

SOUTH-EAST ASIA AND THE PACIFIC REGION AS A SOURCE OF BENEFICIAL ORGANISMS FOR BIOLOGICAL CONTROL

INTRODUCTION

The earliest recorded instance of biological control of a pest by employing a natural enemy from South-East Asia was in 1762 when the mynah bird was introduced from India into Mauritius to control the red locust. Following the spectacular success in the control of the cottony cushion scale in California by the beetle *Rodolia* (*Vedalia*) *cardinalis* introduced from Australia in 1888 interest in exploratory surveys for natural enemies of pests in other areas, including the countries covered in this *Review*, greatly increased. Whilst the results of these surveys and the introductions of parasites and predators from this region into other areas are widely scattered in various publications, unpublished reports, etc., fairly comprehensive reviews of these attempts are available for some countries in this region, *e.g.*, the Philippines (Baltazar, 1963) and Fiji (O'Connor, 1950 *b*). The introductions into Hawaii from various other areas in South-East Asia and the Pacific Region are well documented by Pemberton (1948, 1964), Weber (1951, 1957), Davis (1958–61) and Davis and Krauss (1962–67). Similarly, biological control investigations in Australia and the U.S.A. using natural enemies of pests from this region have been reviewed by Wilson (1960) and Clausen (1956), respectively.

Natural enemies introduced from one area into another within this region and also those sent outside the region to control various pests are considered here. Most of the information on biocontrol agents supplied by Fiji, Indonesia and the Philippines is also summarised in three separate lists.

(1) **Chinese grasshopper**—*Oxya chinensis* (Thunberg) (Orth., Acrididae)

MALAYSIA

In 1930–31 the egg-parasites *Scelio pembertoni* Timb. and *S. serdangensis* Timb. (Hym., Scelionidae) were sent to Hawaii to control *O. chinensis* (= *O. velox* F.), which caused extensive defoliation of sugarcane. *S. pembertoni* became well-established in all areas where the grasshopper was prevalent, and proved very effective in controlling the pest. Within a few years the grasshopper became insignificant. The other species failed to become established (Pemberton, 1948, 1964).

(2) **Locusts**

INDIA

The mynah bird *Acridotheres tristis*, introduced into Mauritius from India in 1762, is reported to have controlled the red locust *Nomadacris septemfasciata* (Serv.) (Acrididae) (Moutia and Mamet, 1946). The locust outbreaks in Mauritian cane plantations during 1962–63 may have been caused, at least partly, by a reduction of the mynah bird population by successive cyclones (Williams, 1964).

In 1966 *Trox procerus* Har. (Col., Trogidae) and *Pimelia inexpectata* (Senac) (Col., Tenebrionidae) which are predacious on *Schistocerca gregaria* Forsk. in India were sent to Hawaii for trial against *Schistocerca vaga* Scudder. *T. procerus* was released on Sand Island. The stock of *Pimelia* was destroyed because the adults nibbled radish and certain other economic plants (Davis and Krauss, 1967). There is no indication that *Trox* is established.

(3) **Cuban laurel thrips**—*Gynaicothrips ficorum* Marchal

PHILIPPINES

The predacious Anthocorid, *Montandoniola moraguesi* (Puton), was introduced from the Philippines into Hawaii in 1964 to control *G. ficorum*. The thrips was first discovered at the Honolulu International Airport in 1964 and spread to several islands, breeding on *Ficus retusa* and *F. benjamina*. Because of its biting and swarming habits the thrips proved to be a public nuisance. The Anthocorid became well-established on Oahu and proved to be an important biocontrol agent in suppressing the thrips. Although it was never released on Maui, Hawaii and Molokai the predator had spread to these islands in 1965 (Davis and Krauss, 1965, 1966).

(4) **Balsam woolly aphid**—*Adelges piceae* (Ratz.) (Hem., Adelgidae)

INDIA

The following predators were shipped to the U.S.A. during 1960–65 by the CIBC, Indian Station: *Chrysopa* spp. (Neur., Chrysopidae), *Leucopis* spp. (Dip., Chamaemyiidae), *Tetraphleps abdulghanii* Ghauri, *T. raoi* Ghauri (Hem., Anthocoridae), *Adalia luteopicta* Muls., *A. tetraspilota* Hope var. *bispilota* Weise, *Adonia variegata* Goeze, *Ballia dianae* Muls., *Coccinella septempunctata*, Genus nr. *Calvia*, *Exochomus uropygialis* Muls., *Harmonia breiti* Mader, *Oenopia sauzeti* Muls., *Pullus* sp. and *Synharmonia conglobata* L. (Col., Coccinellidae).

Predators shipped to Canada during 1959, 1960 and 1965 were: *Chrysopa* spp., *Leucopis* spp., *T. abdulghanii*, *T. raoi*, *A. luteopicta*, *A. tetraspilota* var. *bispilota*, *A. variegata*, *Ballia eucharis* Mulsant, *C. septempunctata*, *C.4-punctata* Pontopp. var. *expallida* Wse., *Chrysopa carnea* Steph., *E. uropygialis*, *E. lituratus* Gorh., *Leis dimidiata* F. ab *dimidia* Hope (Coccinellidae), *Hemerobius adelgivorus* Kimmins (Neur., Hemerobiidae), *Episyrphus* (Deg.), *Metasyrphus confrater* (Wied.) (Dip., Syrphidae) and *S. conglobata*. *T. abdulghanii* was again sent in 1963. None of the predators sent to Canada and the U.S.A. became established.

PAKISTAN

The following predators of *Adelges* were shipped to Canada by the CIBC, Pakistan Station, during 1959–64: *E. uropygialis*, *E. lituratus*, *H. breiti*, *B. eucharis*, *A. tetraspilota* and *T. abdulghanii*.

During the same period the following species were also sent to the U.S.A.: *E. uropygialis*, *E. lituratus*, *B. eucharis*, *A. tetraspilota*, *Leucopis* (*Neoleucopis*) spp., *Chrysopa* sp. (A) and *T. abdulghanii*.

All these predators except *Chrysopa* sp. were released in Canada and the U.S.A. but none became established.

(5) **Aphids** (Hem., Aphididae)

CEYLON

An unidentified parasite species was sent to Western Australia in 1907 to control the cabbage aphid *Brevicoryne brassicae* (L.). This became established and was considered to be the most effective introduction. Although complete success was not obtained, the pest was greatly reduced (Wilson, 1960).

GUAM

Harmonia arcuata (F.) (Coccinellidae), which was controlling *Rhopalosiphum maidis* (Fitch) on corn in Guam, was sent to Hawaii in 1936 but apparently failed to become established (Swezey, 1940).

HONG KONG

In 1895 *Coelophora pupillata*, *C. biplagiata* and *Verania discolor* F. (Coccinellidae) were introduced into Hawaii against aphids. Only *C. pupillata* became established (Swezey, 1925).

Aphelinus sp. sent to California in 1961 for trial against cotton aphid showed promise of establishment initially (Fisher and Schlinger, 1961) but there is no indication that this has been successful.

INDIA

Two shipments comprising 150 adults of the general aphid predator *Menochilus* (*Chilomenes*) *sexmaculatus* (F.) were sent to the U.S.A. in 1954. The predator was bred and colonies were released in Texas and Mexico in 1954 and 1955. Larvae and adults were found in Texas in 1955, after some four generations had developed, but a survey in 1956 showed that the predator had not become established either in Texas or in Mexico (McGough and Noble, 1957).

Aphidius smithi Sharma and Subba Rao (Hym., Aphidiidae) was introduced from India into California in 1958 against *Macrosiphum pisum* (Harris) on lucerne. By 1960 more than 220,000 parasites had been released. It became established in several of the coastal valleys, exerting considerable control of the aphid and later spreading to many of the interior valleys, including the desert regions of southern California. It was also released and recovered in the Central Valley but its populations there were restricted by the scarcity of the host in the summer (Hagen and Schlinger, 1960). The parasite was released in many of the eastern States in 1958–61. It became established at several places, giving an average parasitism of 18% and maximum of 25% (Angalet and Coles, 1966). It appeared to have spread to southern Ontario in Canada from eastern U.S.A. It was reared at Belleville, Ontario, and released in some pea-growing areas of Nova Scotia in 1964. Further investigations in southern Ontario in 1964 showed that the parasite was abundant on lucerne in two counties, where it appeared largely to have replaced *Aphidius pulcher* Baker (Mackauer and Bisdee, 1965) In 1965 *A. smithi* was reared from *M. pisum* on lucerne in central Mexico and since it was not liberated in this area it appeared to have spread there from the U.S.A. (Clancy, 1967).

A. smithi was shipped from California to Hawaii in 1960 to control *M. pisum* on lucerne. Following its liberation in a large lucerne field at Ewa, Oahu, numerous parasitised aphids were observed, indicating quick establishment (Davis, 1961). Within a year spectacular control of the pea aphid on alfalfa was reported in Maui, where the degree of parasitism was extremely high (Simmonds, 1961).

In 1960 *Aphelinus gossypii* Timb. was introduced by the Department of Biological Control, Riverside, U.S.A., and was colonised and recovered from cotton aphid at Riverside (Fisher and Schlinger, 1961).

Natural enemies shipped by the CIBC, Indian Station, to the U.S.A. during 1960–69 for trial against *Myzus persicae* (Sulz.) and *Aphis gossypii* were: *A. smithi*, *Aphidius* sp., *Aphelinus flavipes* Forst., *Aphelinus* spp. aff. *flavipes* Kurdj., *Aphelinus* ? *mali* (Hald.), *Praon myzophagum* Mack. (Aphidiidae), *Binodoxys indicus* S. & S. (Aphidiidae), *Coccinella septempunctata*, *Menochilus sexmaculatus*, *Jauravia* sp., *Scymnus* sp. (Coccinellidae), *Eumicromus navigatorum* M. (Neur., Hemerobiidae), *Leucopis nigricornis* Egg., *L. puncticornis* Meigen (Dip., Chamaemyiidae) and *Lipolexis scutellaris* Mack. (Aphidiidae). Of these only *C. sexmaculata* was released in 1960 and *E. navigatorum* in 1961. No recoveries have been made.

The parasitic fungus *Cephalosporium aphidicola* Petch supplied from CIBC, Indian Station, to the Glasshouse Crops Research Institute, England, in 1969 for trial against aphids in glasshouses, was evaluated on behalf of G.C.R.I. by Dr. W. Wilding of the Bee Department of Rothamsted. The tests showed that a water suspension of the fungus containing $1 \cdot 5 \times 10^7$ spores per c.c. caused 96% mortality of aphids on bean plants when 3 c.c. of this dilution was sprayed on to each of three 5″-high bean plants carrying 25 aphids, in a series of experiments with different dilutions. The same concentration induced a severe epizootic of *A. gossypii* on 2′-tall cucumber plants within 4–5 days in another series of experiments at G.C.R.I. Similar concentrations are being tried to control *M. persicae* on chrysanthemums (N. W. Hussey, pers. com.).

In 1969 the Coccinellids *C. septempunctata*, *Coccinella repanda* Thnb. and *Synonycha grandis* Thnb. were sent from India to West Indian Station, CIBC, for trial against the sugarcane aphid *Sipha flava* Forbes in Trinidad. These fed readily on *S. flava* but failed to reproduce. All these species were released on Caroni Estates but not recovered.

C. septempunctata was also sent to G.C.R.I., England, for trial against aphids in glasshouses. In 1968 this predator was also shipped to the Bahamas for trial against *S. flava*.

Two thousand adults of *Oenopia sauzeti* (Coccinellidae) were sent to New Zealand in 1968 for trial against cabbage and cereal aphids, and are still being bred in the laboratory there. Seven hundred pupae of *Lasiopticus pyrastri* L. (Syrphidae), *Episyrphus balteatus* and *Metasyrphus confrater*, 1,800 puparia of Chamaemyiids and 2,500 eggs and 94 cocoons of *Chrysopa* spp. were also sent to New Zealand during 1968–69.

TAIWAN

The following natural enemies were sent to California from Taiwan: three species of Coccinellids, *Lemnia personata* (Ws.), *L. swinhoei* (Crotch.) and *Propylea japonica* Thnb. and a species of *Aphelinus* against *Aphis spiraecola*; a species each of *Trioxys* and *Aphelinus* against cotton aphid and an aphidiine wasp *Ephedrus* sp. reproducing very well on rose aphid. These insects were reported initially as having shown promise of establishment (Fisher and Schlinger, 1961) but the latest available information is that only *Aphelinus* sp. on *A. spiraecola* is established but has had little effect on this pest (Robert van den Bosch, pers. com.).

(6) **California red scale**—*Aonidiella aurantii* (Mask.)

BURMA

Aphytis fisheri DeBach was shipped to California from Burma in 1957 to control the red scale. During 1957–58 the parasite was bred and released in large numbers over 200 plots in all red-scale-infested citrus-producing counties from Fresno to San Diego. Recoveries of the parasite were made in the San Joaquin Valley and southern California.

Another parasite sent to California from Burma and released was *Aphytis* sp. near *hispanicus* (Mercet), but this was not recovered (DeBach and Landi, 1959).

HONG KONG

In 1900 George Compere introduced a parasite, presumably *Aspidiotiphagus citrinus*, from Hong Kong into California. It was released in the citrus orchards of Los Angeles and Orange counties. In 1905 Compere collected *Comperiella bifasciata* and an *Aphytis* sp. presumably *lingnanensis* Compere in the vicinity of Hong Kong and sent them to California. These were released against the California red scale but none became established (Flanders *et al.*, 1958).

INDIA AND PAKISTAN

Aphytis melinus DeBach was obtained from India and Pakistan in 1956 and 1957 for introduction into California, U.S.A. This was mass-produced there and about two million adults were colonised on *A. aurantii* on citrus during 1957 and 1958. Numerous field recoveries were made in 1958. *A. melinus* is now well-established in California and along with *Aphytis lingnanensis* imported from China in 1947–48, has given partial control of the scale (DeBach, 1959, 1964).

Over 2,000 scales parasitised by *Aphytis* sp., *A. melinus*, *A. citrinus*, *Azotus* sp., *Prospaltella* sp. and *Comperiella* sp. and about 300 adults of *Aphytis* sp. were sent from West Pakistan to California in 1960 and 1961. A number of *Comperiella* sp. were reared but these could not be bred successfully on either the California red scale or the yellow scale. Breeding of the other parasites was not attempted because of the small number of living specimens obtained.

From California *A. melinus* was introduced into South Africa but establishment there is doubtful (Annecke, 1969).

Chilocorus bipustulatus was sent to South Africa in 1963 from West Pakistan for trial against red scale.

Chilocorus circumdatus and *C. hauseri* Wse. were sent to the U.S.A. from India in 1960. They were bred and field liberations made in southern California. No recoveries have been made.

C. circumdatus and *C. kuwanae* (origin Japan) were sent from India to S. Africa in 1965. It is doubtful if any of the *Chilocorus* spp. shipped from India and Pakistan is established in S. Africa (Annecke, 1969).

In 1932–33 *Pharoscymnus horni* Wse., a predator on red scale, was sent to California. It failed to become established (Compere, 1961).

TAIWAN

A. melinus was shipped to California and in 1952 several thousand adults were released in the interior valleys of southern California. It failed to become established (Flanders, 1964).

In 1949 a red scale strain of *Prospaltella perniciosi* was sent to California. It became established and is now complementing the work of *Aphytis* in controlling the red scale (Clausen, 1956; DeBach, 1969).

(7) **Florida red scale**—*Chrysomphalus ficus* Ashm.

HONG KONG

In 1956 *Aphytis holoxanthus* DeBach (previously mistaken for *A. lingnanensis*) was shipped from Hong Kong to Israel to control *C. ficus*, a major citrus pest there. Early establishment followed and the scale was completely controlled by 1959 (DeBach, 1960).

In 1960 *A. holoxanthus* was sent to Florida from Israel (*via* California where it was received in 1959) and liberated in eight orange groves. It became established and dispersed widely, indicating that local conditions were very suitable for it. It was also recovered from *C. ficus* on plants other than citrus. *A. holoxanthus* is now an important factor in the biological control of the red scale in Florida (Muma, 1969).

A. holoxanthus was introduced into South Africa from California in 1962. Releases were made in a number of citrus orchards in 1962–63 and from 1964 to 1968. It has become widely established and given complete control of the pest (Greathead, 1971).

INDIA

Chilocorus nigritus introduced from India into the Seychelles in 1938 gave very good control of the Florida red scale (Vesey-Fitzgerald, 1953).

(8) **Purple scale**—*Lepidosaphes beckii* (Newm.)

TAIWAN

In 1948–49 *Aphytis lepidosaphes* Comp. and in 1950–51 a *Physcus* sp. were sent to California where these species, particularly *A. lepidosaphes*, were successful against *L. beckii* causing considerable scale mortality every year. Using integrated control methods, the cost of controlling the purple scale in test plots was reduced to less than half of that before the parasite was introduced (Clausen, 1956; DeBach and Landi, 1961).

(9) **Olive scale**—*Parlatoria oleae* (Colvée)

P. oleae has been an important pest of olive in California since its establishment near Fresno about 1934. It is also a major pest of many other crops, ornamental shrubs and trees.

In 1951, A. M. Boyce sent to California 63 separate lots of scale material from collections made in India, Pakistan, Afghanistan, Iran, Iraq, Syria, Egypt, Lebanon, Cyprus, Israel, Greece and Spain. Of the seven species of entomophagous insects obtained the most effective was *Aphytis maculicornis* (Masi). The Persian strain of this parasite greatly reduced the population of *Parlatoria*. In spite of its unsatisfactory performance on the summer brood of female scales, *Aphytis* gave a high degree of commercial control of olive scale in many groove (Huffaker *et al*, 1962).,

Another parasite of *P. oleae*, which was later described as *Coccophagoides utilis* Doutt, was collected by Dr. DeBach from Parachinar, Pakistan, in 1957 (Doutt, 1966). It has since been released against the olive scale in several areas of California and become established. Kennett *et al.* (1966) found that *C. utilis* and *A. maculicornis* operating together gave a very high degree of control.

(10) **San José scale**—*Quadraspidiotus perniciosus* (Comstock)

INDIA

Chilocorus bijugus Muls. and *C. kuwanae* (of Japanese origin) were sent to Switzerland in 1961 and released but no recoveries were made.

Prospaltella perniciosi and *Aphytis diaspidis* were sent to New Zealand in 1960 and were released. But recoveries from many areas indicated that the former parasite was already present in New Zealand prior to these introductions. *A. diaspidis* became established.

PAKISTAN

Aphytis sp. (*proclia* group) from West Pakistan was shipped to the All-Union Institute of Plant Protection, Leningrad, USSR, in 1961 for trial against San José scale.

During the winter of 1961–62 the parasite was bred in the insectary and in the summer of 1962–63 it was tested under natural conditions in the Slavyansky District, Krasnodar Krai. Two to four thousand adult parasites were released per tree in apple orchards infested with scales.

During the first year of colonisation parasitism in the release areas was 18–32%, but in the spring of 1963 it never exceeded 9·3% since *Aphytis* mortality was high during the winter. During the following yearly releases the parasite destroyed ⅓ of the population of female scales on the test trees.

It was suggested that it would be useful to have seasonal colonisation of *Aphytis* and also to facilitate its activities by planting nectar-bearing plants for imaginal feeding (Mrs. V. A. Shchepetilnikova, pers. com.).

(11) ***Odonaspis penicilata*** (Green)

PAKISTAN

Habrolepis sp., *Azotus* sp. and an unidentified Chalcid were sent to Bermuda in 1968 and 1969.

(12) **Coconut scale**—*Aspidiotus destructor* Sign. and other *Aspidiotus* spp.

CEYLON

In 1939 *Chilocorus nigritus* was sent to Mauritius and 111 beetles were liberated against *A. destructor*. It became established and was highly successful in controlling the scale (Moutia, 1944; Moutia and Mamet, 1946).

C. nigritus collected by N. L. H. Krauss at Chilaw, Ceylon was released in Oahu, Hawaii against *Aspidiotus* spp. in 1958 (Davis, 1959). It is not known to be established.

GUAM

Cryptogonus orbiculus Gyll. var. *nigripennis* Weise introduced into Fiji from Guam to control *A. destructor* failed to become established. In 1923 this Coccinellid was also sent to Saipan (Marianas) but whether it is established there or not is uncertain (Hoyt, 1957).

TAHITI

During 1920–25 colonies of the parasites *Aphytis chrysomphali* and *Aspidiotiphagus citrinus* were introduced from Tahiti to control *A. destructor* in Fiji. Both became established (Taylor, 1935).

(13) **Other Diaspine scales**

GUAM

Telsimia nitida Chapin, a Coccinellid predator of *A. destructor* on Guam was introduced into Hawaii in 1936 to control *Pinnaspis buxi* Bouché attacking coconut and other palms. Some 200 beetles were sent in the first consignment and several hundred later. These were liberated in the field and became established. In a few years complete control of the scale was achieved and it is now considered a minor pest (Swezey, 1940; Pemberton, 1948).

INDIA

Chilocorus nigritus was shipped from Coimbatore (India) to the Seychelles in 1938. Forty reached alive and with this initial stock it was multiplied and liberated in the field against various Diaspine scales, on which they fed readily. By 1939 it became well-established in the Seychelles and in 1940 it was more abundant than the indigenous predator *C. distigma* (Klug.). The introduced species effectively controlled *Pinnaspis buxi* and *Ischnaspis longirostris* (Sign.) (Tirumala Rao *et al.*, 1954; Vesey-Fitzgerald, 1953).

In 1960, *Chilocorus bijugus* and *C. hauseri* were sent to the CIBC, West Indian Station, for trial against the peach scale *Pseudaulacaspis pentagona* Targ. in Bermuda.

PAKISTAN

Some 1,030 larvae and pupae of *Aphytis* sp. nr. *citrinus* Compere parasitic on *Aonidiella* spp. and 700 larvae and pupae of *Comperiella bifasciata* on *Aonidiella citrina* (Coq.) and 480 *Aneristus ceroplastae* How. on *Coccus hesperidum* L. were sent to the University of California during 1968–69.

(14) **Rhodes grass scale**—*Antonina graminis* (Mask.)

INDIA

In 1959 two shipments containing over 2,100 scales parasitised by the Encyrtid *Neodusmetia sangwani* (Subba Rao) were sent to the U.S.A. The parasite was bred in the laboratory and released in various places in southern Texas during 1959–60. It became established at several places (Dean *et al.*, 1961). Dr. M. F. Schuster of Texas, A.M. College, reported the parasite to be successful in reducing the scale population by 46–79%, giving yield increases of production of forage by 30% (Simmonds, 1967).

N. sangwani was also sent to Bermuda in 1968. More than 3,000 adults were liberated in various parts of the island over a period of five months and the parasite was first recovered in November 1968. It seems to have become well-established in at least two locations (I. W. Hughes, pers. com.).

(15) **Guava mealy scale**—*Pulvinaria psidii* Maskell

INDIA

Coccophagus bogoriensis Konigsberger (Hym., Eulophidae), *Coccophagus* sp., Genus near *Mesopeltis* (Hym., Pteromalidae), *Metaphycus* sp. (Encyrtidae), *Microterys* sp. (Encyrtidae), *Tetrastichus* sp. (Eulophidae), *Scymnus coccivora* Ayyar (Col., Coccinellidae) and *Leucopis luteicornis* Mal. (Dip., Chamaemyiidae) were sent to the CIBC Californian Station for screening, breeding and subsequent supply to Bermuda. *Eublemma scitula* Ramb. (Lep., Noctuidae), *Spalgis epius* Westw. (Lep., Lycaenidae) and the Coccinellids *S. coccivora* and *Cryptolaemus montrouzieri* were sent directly to Bermuda. *C. montrouzieri* (of Australian origin) introduced into Bermuda in 1956–57 has been reported to be well-established and to be giving control of the scale.

C. montrouzieri shipped to Hong Kong and released against citrus mealybugs was found to feed on *P. psidii* (So, 1967). However it was not available in the field in 1968 when one of the authors (Rao) made a search for it during a visit to Hong Kong.

(16) **Pink mealybug**—*Saccharicoccus sacchari* (Ckll.)

INDIA

The Coccinellids *C. montrouzieri*, *Nephus* sp. and a *Hyperaspis* sp., were sent to the Bahamas and the Barbados in 1968–69 and were liberated. In the Bahamas *C. montrouzieri* has been found on a variety of soft scales on guava near the release sites. Subsequently it was recovered also from *Saccharicoccus* on sugarcane and as larvae have also been found feeding on the mealybug it appears to have become established (Beg, M. N., Rep. of Entomologist, 1967–68, Bahamas Agric. Ind. Ltd., Sug. Project).

Scymnus apiciflavus (Motsch.) (Coccinellidae) was shipped to Hawaii from Malaysia in 1931, bred extensively in the laboratory at Honolulu and widely liberated against *S. sacchari*. It failed to become established (Pemberton, 1964).

PAKISTAN

Coccinella septempunctata was sent to the Bahamas in 1968 for release against *S. sacchari*. It is not known whether any releases were made.

(17) **Fluted scale**—*Icerya purchasi* Mask.

INDIA

Rodolia cardinalis (origin Australia) and *Rodolia* sp. were sent to Portugal in 1961 for introduction into Principe (Portuguese West Africa). The former was also sent to Hong Kong in 1961. These were also sent to Sao Tomé (North-West Africa) in 1963. *R. cardinalis* has become established and given good control of the fluted scale in Hong Kong (So, 1967; Simmonds, 1971).

TAIWAN

In 1911, *R. cardinalis* (originally introduced from California and Hawaii in 1909) was sent to Japan where it successfully controlled *I .purchasi* (Watanabe, 1958). In 1928 it was shipped to the Palau Islands and became established there (Hoyt, 1957).

(18) **Hibiscus mealybug**—*Maconellicoccus hirsutus* (Green)

INDIA

Hyperaspis maindroni Sic., *Brumus suturalis, Scymnus coccivora, S. pallidicollis* Muls. and *Verania discolor* were sent to New Guinea during 1966–69. Releases were made but only *H. maindroni* is known to be established.

(19) **Other Coccids**

HONG KONG

In 1925, *Anagyrus dactylopii* (How.) was introduced from Hong Kong into Hawaii against the mealybug *Nipaecoccus vastator* (Mask.). This was a complete success and the mealybug became very scarce (Swezey, 1928; Fullaway, 1952).

INDIA

In 1958, N. L. Krauss collected a *Scymnus* sp. and an unidentified Encyrtid at Calcutta and sent them to Hawaii for trial against mealybugs. Field releases were made on Oahu (Davis, 1959). It is not known whether these have become established.

Two *Scymnus* spp., predacious on *Planococcus lilacinus* (Ckll.) were introduced from Coimbatore into East Africa in 1937 to control *Planococcus kenyae* (Le Pelley). Both failed to become established. *Brumus suturalis*, a *Leucopis* sp. and an *Anagyrus* sp. were also shipped to Kenya in the same year but there is no record of any liberation (Le Pelley, 1959).

An Indian strain of the entomophagous fungus *Cephalosporium lecanii* Zimmerman (Moniliales) sent to Seychelles from the Commonwealth Mycological Institute in 1933 is reported to have become established and to be responsible for the successful control of the coffee green scale *Coccus viridis* at higher altitudes. The fungus is common on coccids on cinnamon, citrus and coffee (Greathead, 1971).

C. montrouzieri was sent to Hong Kong in 1961 to control the citrus mealybugs *Nipaecoccus vastator* and *Pseudococcus* spp. The predator has become well established (Simmonds, 1971). In 1960, *Scymnus coccivora* and *C. montrouzieri* were sent to Sikkim. In 1968–69, *C. montrouzieri*, *Chilocorus hauseri* and *C. circumdatus* were sent to Cyprus. Whether any of these Coccinellid species has become established remains to be investigated.

MARIANAS

Rodolia pumila introduced from the Marianas into the Caroline Islands during 1947–49 gave satisfactory control of *Icerya aegyptiaca* (Gardner, 1958). It was also introduced into the Marshall Islands in 1947–48 and became established (Hoyt, 1957).

(20) **Sugarcane leaf-hopper**—*Perkinsiella saccharicida* Kirkaldy

TAIWAN

An egg-parasite, *Ootetrastichus formosanus* Timberlake, was introduced from Taiwan into Hawaii in 1916. From an initial stock of 20 females and a few males it was multiplied and liberated in large numbers against the sugarcane leaf-hopper. It became established and gave considerable control of the pest on many plantations except in the rainy districts. In the same year another *Ootetrastichus* sp. was introduced from Taiwan but this failed to become established (Pemberton, 1964; Swezey, 1936).

(21) **Corn leaf-hopper**—*Peregrinus maidis* (Ashmead)

GUAM

The mirid egg-predator *Tytthus* (*Cyrtorhinus*) *lividipennis* (Reuter) was introduced from Guam into Hawaii in 1939, 1951 and 1952 to control the corn leaf-hopper. It became established on Oahu and Hawaii and was particularly active on the former island in 1959 (Davis, 1960).

(22) **Citrus blackfly**—*Aleurocanthus woglumi* Ashby

INDIA AND PAKISTAN

Amitus hesperidum, *Prospaltella opulenta*, *P. clypealis* and *P. smithi* were sent from India and Pakistan to Mexico during 1948–50 to control the citrus blackfly. These became established. Economic control was achieved practically all over the country with the exception of small areas on the west coast. *A. hesperidum* was most effective generally while *Prospaltella* spp. controlled the pest under special and limited conditions (Clausen, 1958).

MALAYSIA

In 1930, Cuba obtained *Eretmocerus serius* from Malaysia and this parasite gave complete control of *A. woglumi* and has thence been sent to other areas—Barbados, the Bahamas, Costa Rica, Haiti, Jamaica, Panama, the Seychelles, East and South Africa.

Prospaltella divergens Silv., *P. smithi* and *E. serius* were shipped to Mexico in 1948–49 (McIntosh, 1951; Wilshaw, 1949). While the last two species became established there is no indication that the introduction of *P. divergens* was successful. *E. serius* successfully controlled the citrus blackfly in the West Indies and parts of Central America but failed in western Mexico probably because of long periods of drought. Very good control of *Aleurocanthus* was achieved in the Seychelles and in Africa (Clausen, 1952 and 1958; Russell, 1962; Simmonds, 1969 *b*).

The Coccinellid predator *Catana clauseni* Chapin was also introduced into Cuba from Malaysia in 1930 and widely colonised. In 1937 the predator was shipped to the Bahamas and over 1,000 adults and larvae were released at Nassau. It has complemented the work of *Eretmocerus* in controlling the pest (Clausen, 1956; Richardson, 1948).

(23) **Citrus white-fly**—*Dialeurodes citri* (Ashm.)

INDIA AND PAKISTAN

In 1911, Woglum obtained sufficient material of *D. citri* and its natural enemies to ship to Florida. Young orange trees were infested with *D. citri* under a canvas awning which kept out other undesirable pests. Five 'Wardian cases' of natural enemies of the white-fly were despatched from Lahore (Pakistan). However, only 28 healthy *Catana parcesetosa* (Sicard) (= *Cryptognatha flavescens* Motsch.) (Col., Coccinellidae) and 8 adults and several pupae of *Prospaltella lahorensis* (How.) survived the journey. Unfortunately, it was during the winter when white-flies in Florida were in the dormant pupal stage, and in spite of all efforts to rear them under laboratory conditions both parasites and predators were dead by January 1912. From Saharanpur (India) 200 *C. parcesetosa* feeding on *D. citri* were sent in two consignments. All died in transit (Woglum, 1913).

Woglum (1913) reported a brown fungus, *Aegerita webberi* Fawcett, attacking *D. citri* at Saharanpur, but this had been introduced into Florida several years earlier. Cultures of the fungus were widely distributed in Florida but the real value of this artificial dissemination was uncertain and so the programme was discontinued in 1943 (Clausen, 1956).

Misra (1924) mentions that *Aphelinus fuscipennis* Howard was shipped to the U.S.A. in 1914 for trial against *D. citri*. It is not known whether the parasite was released but *A. fuscipennis* is a synonym of *Aphytis proclia* (Walker), which occurs in the U.S.A. (Muesebeck *et al.*, 1951).

In 1968–69 more than 25,000 pupae of *Prospaltella* sp. on *D. citri* were sent to the University of California by the CIBC, Pakistan Station. *Prospaltella* sp. was released directly in the field in California while laboratory cultures of other parasites have been established.

In 1969 parasitised nymphs of *D. citri* collected in north India were sent to the University of California by the CIBC, Indian Station. Two species of *Prospaltella*, one presumably *P. lahorensis* and the other a new species, were reared from them. Both have been released and become established in the field (Paul DeBach, pers. com.). Nymphs of *Dialeurodes kirkaldyi* (Kotinskyi) on jasmine parasitised by *Eretmocerus* sp. were also sent for trial with this parasite.

(24) **Green bug**—*Nezara viridula* (L.)

PAKISTAN

Asolcus seychellensis Kieffer (Hym., Scelionidae), *A. striaticeps* Dodd., *Asolcus* sp. and *Hadronotus antestiae* Dodd. (Scelionidae) were shipped to Australia in 1961 by the CIBC

Pakistan Station. *Asolcus* sp. was easily bred on egg-masses of *N. viridula* and released widely throughout Australia. Several shipments were also made to Hawaii, where releases were made. Unfortunately it is not possible to comment on the possible establishment of this *Asolcus* sp. because it is indistinguishable from *A. basalis* (Woll.), another egg-parasite introduced from Egypt into Australia and thence into Hawaii and successfully established in both (E. McC Callan, pers. com.).

A. seychellensis, two *Asolcus* spp., *H. antestiae* and two *Anastatus* spp. were sent to the CIBC, West Indian Station in 1961. *Anastatus* were released in Antigua, Nevis, Montserrat and St. Vincent, but not recovered. In Trinidad the progeny of *Anastatus* were all males when reared on *N. viridula* but a high ratio of females was obtained on the larger eggs of *Edessa meditabunda* F. (Pentatomidae). It was hoped that *Anastatus* might become established on this latter species if it failed to do so on *Nezara*. However, no recovery has been made from either host. The other species of parasites failed to breed in the laboratory and were not released.

(25) ***Popillia*** spp.

INDIA

Parasites of *Popillia* spp. and related Scarabaeidae were investigated in India from 1920 to 1929 with a view to their introduction into the U.S.A. to control the Japanese beetle *Popillia japonica* Newm. A Pyrgotid fly, *Adapsilia flaviseta* Aldrich, was found to parasitise the adults of *Popillia cupricollis* Hope and, occasionally, *P. cyanea* Hope and *P. macclellandi* Hope. A total of 21,462 parasite puparia was shipped to the U.S.A. Two species of Scoliidae, *Tiphia matura* Allen and Jaynes (35,270 cocoons) and *T. pullivora* A. & J. (81,657 cocoons) were also shipped. A Tachinid parasite of adult Scarabaeid beetles, *Hamaxia incongrua* Wlk., a Dexiid larval parasite, *Prosena siberita* (F.) and two other Scoliid larval parasites, *Tiphia assamensis* A. & J. and *T. clauseni* A. & J. were also studied but no shipments were sent to the U.S.A (Gardner and Parker, 1940). None of the three species introduced became established (Clausen, 1956).

(26) **Rhinoceros beetle**—*Oryctes rhinoceros* (L.)

CEYLON

During 1957–58 *Rhabditis* sp. nr. *maupasi*, a nematode parasitising all stages of *Oryctes* and other Lamellicorn beetles, was sent to Fiji. The predacious Elaterid beetles *Lanelater* (= *Agrypnus*) *fuscipes* and *Alaus speciosus* were introduced into Western Samoa in 1955 and successfully established. Both species are closely associated in the field but the control value of *Lanelater* appears to be greater because this predator is more closely associated with *Oryctes* breeding sites (Hoyt and Catley, 1967).

INDIA

The Carabid predators *Pheropsophus hilaris sobrinus*, *P. lissoderus* Chaud., *P. occipitalis* Macl. and *P. stenoderus* Chaud. were sent to Mauritius in 1962, and again during 1964–67.

Scarites dubiosus (Carabidae), *Scarites* sp. and *Hister* sp. (Histeridae) were also sent in 1962. It has been reported that *P. hilaris sobrinus* and *P. occipitalis* have become established against *Oryctes* and that they are also useful against other pests like *Clemora smithi* Arr. and *Cosmopolites sordidus*. Several consignments of *P. hilaris sobrinus*, *S. dubiosus*, *Oxylobus punctatosulcatus*, and a few other species of Scaritids were sent for trial releases against *Oryctes* in the South Pacific area. Although its status as an *Oryctes* parasite appeared doubtful *Campsomeris azurea* Chr. (Hym., Scoliidae) was also sent at the specific request of the South Pacific Commission authorities. In addition, a small number of *Scolia quadripustulata* F. var. *barmanica* Magr. were also supplied for trial.

Many of these were liberated in different South Pacific territories but no establishment was recorded. In many instances, the actual release of specimens was not very well effected and follow-up surveys have not been conducted (A. Catley, pers. com).

P. hilaris sobrinus was also sent to Malaysia for field trials but the results are not known.

MALAYSIA

In 1939, *Catascopus fascialis* was introduced into Samoa from Malaysia but did not seem to have become established there (Simmonds, 1952).

In 1948, *Scolia patricialis* Burm. var. *plebeja* Grib. parasitising *Oryctes* larvae in Malaya was introduced into the Palaus, but was not known to have become established (Bryan, 1949).

Scolia procer was shipped to Mauritius in 1966 through the CIBC Indian Station. Thirteen females and eight males were released. There has been no recovery.

PAKISTAN

In 1967, *Platymeris laevicollis* was sent to Mauritius and Iran. No information is available as to what happened to this material. Between 1962 and 1967 the predator was shipped to Mauritius in 25 shipments (1,435 eggs and 127 nymphs and adults). Releases were made but there is no report of any recovery (Greathead, 1971). This predator was also sent to India in 1968 for multiplication and release in Androth Island in the Laccadives.

(27) **Yam beetles**—*Heteroligus meles* (Billb.) and *H. appius* (Burm.) (Col., Dynastidae)

INDIA

In 1968 *P. hilaris sobrinus* was sent to Nigeria for trial against yam beetles. The work is continuing.

(28) **White grubs**

PHILIPPINES

In 1915–17, two Scoliid parasites, *Campsomeris marginella modesta* and *Tiphia segregata* Cwfd., were sent to Hawaii to control *Anomala orientalis* (Waterhouse). They were liberated and became established on *Anomala* grubs, but also parasitised the grubs of the Chinese rose beetle *Adoretus sinicus*. Whilst *Campsomeris* became established in 1916 it was only in 1934 that *Tiphia* was recovered. It is noteworthy that establishment of the latter resulted from the liberation of only 6 females and a few males. However, these parasites gave little control.

In 1931–32 about 24,000 *Adoretus* grubs parasitised mostly by *Tiphia lucida* Cwfd. were shipped to Hawaii. From this material a large number of adult *Tiphia* were reared and liberated, but without establishment (Pemberton, 1964).

TAIWAN

A species of *Tiphia* and a Tachinid, *Hamaxia incongrua*, were sent to Hawaii in 1927 for trial against *A. sinicus*. A total of 895 *Tiphia* and 38 adults of *H. incongrua* which reached Honolulu in good condition were liberated, but no recoveries were made (Pemberton, 1948).

(29) ***Epilachna*** sp.

INDIA

Pediobius foveolatus (Cwfd.) and *Tetrastichus ovulorum* Ferr., parasites of *Epilachna* in India, were sent to the U.S.A. in 1966 for trials against the Mexican bean beetle *E. varivestis*. *P. foveolatus* was released in some eastern states in 1967 (Angalet *et al.*, 1968). It gave up to 50% larval parasitism, but could not overwinter successfully. It is now being tested in the most southern areas of the U.S.A. Search is being made in north India for a possible winter tolerant race of *P. foveolatus*.

(30) **Banana weevil borer**—*Cosmopolites sordidus* (Germ.)

MALAYSIA

Shipments of the Hydrophilids *Dactylosternum hydrophiloides* and *D. abdominale* F., the larvae of which are predacious on the banana borer, were sent from Malaysia to Jamaica during 1937–39. Liberations were made and a few larvae of both species recovered in 1938 (Anon., 1939; Edwards, 1940). Further distribution of eggs, larvae and adults of *D. hydrophiloides* was made during 1941–42 (Edwards, 1942). Since the pest continues to be important these predators have apparently not been successful. In 1938 and 1939 *D. hydrophiloides* was also sent to Australia where it became established and was believed to be of some value in controlling the borer (Corbett and Pagden, 1941; Wilson, 1960). The predator was introduced into the Palaus in 1948 but is not known to be established there (Gardner, 1958).

(31) **Coconut leaf-miner**—*Promecotheca papuana* (Csiki)

NEW HEBRIDES

In 1938, an unsuccessful attempt was made to introduce *Pediobius parvulus* into the Territory of Papua and New Guinea from the New Hebrides to control *P. papuana* (Froggatt, 1939). However, the parasite was introduced there from Fiji in the same year (O'Connor, 1940 *a*).

(32) **Coconut leaf—Hispids**—*Brontispa* spp.

INDONESIA

Tetrastichus brontispae which attacks *Brontispa* spp. in Indonesia and other Pacific Islands was introduced from Java into Saipan and Rota in 1948 to control *Brontispa mariana*. It became established on both islands. Field control on Saipan was obtained in six months after release of 25 colonies, each numbering about 200. *Haeckeliana brontispae* sent to Saipan and Rota along with *T. brontispae* was also released but not recovered (Lange, 1950; Bryan, 1949; Clausen, 1951).

T. brontispae was also introduced into the Solomon Islands in 1938 but without significant results (O'Connor, 1940 *b*). In 1939 it was successfully introduced into New Britain from the Solomon Islands. Though established it is apparently of little or no value (Wilson, 1960). Recently, this species was introduced from Tahiti and released on the Russell Islands. It has become reasonably well-established in a small area. Attempts are being made to breed the parasite and release over a large area (Anon., 1969).

MALAYSIA

Bryan (1949) reported that *H. brontispae* and *T. brontispae*, parasitising the closely related *Plesispa nipae* Maulik in Malaya, were shipped to Saipan and Rota in 1948. Another parasite, *Achrysocharis* sp., from the Hispid *Wallaceana palmarum* (Gestro) was also introduced but it did not survive (Lange, 1950).

(33) **Fruit-flies**—*Dacus* spp., *Ceratitis capitata* (Wied.) and *Strumeta tryoni* (Frogg.) (Dip. Tephritidae)

A very large number of shipments of fruit-fly parasites have been sent to Hawaii from several countries in South-East Asia and the Pacific Region. A detailed account of these shipments has been given by Clausen *et al.* (1965). Many of these shipments from different sources contained the same parasite species. It is not possible to indicate how many of individual species from each source were liberated. According to Pemberton (1964), though the Oriental fruit-fly *Dacus dorsalis* continues to be a pest in Hawaii its overall population is very much less than before these introductions and definite economic benefit has attended the establishment of at least three of the imported parasite species.

CEYLON

Dirhinus auratus and *Spalangia* sp. were introduced into Mauritius in 1939 and field releases made in 1939 and 1940 against the local fruit-flies, especially *Dacus* spp. No recoveries were made (Moutia and Mamet, 1946). In 1951, some 128,400 puparia of *Dacus cucurbitae* and about 1,000 *D. dorsalis* were sent to Hawaii for rearing parasites, from which the following were obtained: *Opius fletcheri*, *O. watersi*, *Spalangia* sp. and *Psilus* sp. from the former, and *Aceratoneuromyia indicum* and *Spalangia* sp. from the latter (Clausen *et al.*, 1965).

INDIA

Borg (1932) considered that attempts to establish *A. indicum* in Malta and Sicily to control *C. capitata* were not successful because the species was unable to survive the winter. Its introduction into Australia, first in 1907 and again in 1935–37, to control *C. capitata* and the Queensland fruit-fly *S. tryoni* was also a failure. Several unidentified fruit-fly parasite species were introduced from India into Australia in 1903 and 1906–07, and *O. persulcatus*, *O. incisi* and two other *Opius* spp. in 1935. None of these became established (Wilson, 1960).

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D. auratus, a pupal parasite of *D. cucurbitae* in South India, was sent to Ceylon in 1936. It was bred in large numbers and released against *Dacus* spp. and has become established (Hutson, 1937, 1939 *a*).

The Braconid larval parasite *O. fletcheri* sent to Hawaii in 1916 became well-established and effected considerable control of the melon-fly *D. cucurbitae* infesting the small fruits of the balsam apple *Momordica balsamina* L., particularly where the plant occurred in waste areas, but the parasite gave little control of the fly on melons, cucumbers, squash, tomatoes and other fruits. Therefore, in 1949, *O. watersi* was sent from India, readily bred on melon-fly larvae and liberated in the field. There was no evidence of establishment (Swezey, 1928; Pemberton, 1964).

In 1950, large numbers of fruit-fly puparia (791,436) were shipped to Hawaii from north India, and they yielded *Bracon fletcheri* Silv., *Opius incisi*, *O. watersi*, *O. longicaudatus*, *O. fletcheri*, *O. vandenboschi*, *Cratospila* sp. (Braconidae), *Spalangia afra* Silv., *S. endius* Wlk., *Dirhinus luzonensis* Roh., *D. giffardii*, *Pachycrepoideus vindemmiae* (Rond.) (Pteromalidae), Cynipidae sp., *O. carpomyiae* (Silv.), *Psilus* sp. (Hym., Diapriidae), *Trichopria* sp. (Diapriidae) and *O. oophilus*. *A. indicum* collected at Coonoor (South India) was also sent to Hawaii in 1950 (Weber, 1951).

From a further 1·25 million puparia received in Hawaii from South India in 1950 and 1951 the following parasites were reared:

Opius persulcatus, *O. oophilus*, *O. compensans*, *O. incisi*, *O. manii* Full., *O. carpomyiae* *A. indicum*, *S. endius*, *S. afra*, *S. grotiusi* Gir., *D. giffardii*, *D. luzonensis*, *P. vindemmiae*, *Trichopria* sp., *Trybliographa daci* Weld (Hym., Cynipidae), *Pseudeucoila* spp. (Cynipidae), *Cothonaspis* spp. (Cynipidae), two *Psilus* spp., *Halticoptera* sp. (Pteromalidae), unidentified Alysiinae (Braconidae), *Tachinaephagus* sp. (Encyrtidae) and *Cratospila* sp. (Clausen *et al.*, 1965).

MALAYSIA

Spalangia sp., a pupal parasite of *D. dorsalis* in Malaya was sent to Ceylon in 1936 and a large number of this parasite was liberated in the field against *Dacus* spp. This has become established (Hutson, 1937, 1939 *a* and *b*).

In 1948 and 1949 some 19,000 fruit-fly parasites, mostly of *D. dorsalis*, were shipped from Malaya to Hawaii. These included: *O. persulcatus* (not the true *persulcatus* but a complex consisting of *O. oophilus* and *O. vandenboschi*), *O. incisi*, *O. longicaudatus malaiensis* Full., *O. fletcheri*, two *Tachinaephagus* spp., *A. indicum*, *P. vindemmiae*, *S. endius*, *S.* sp. nr. *simplex* Perkins, *T. daci*, *Pseudeucoila* sp., *Pilinothrix* sp. (Cynipidae) and *Psilus* sp. Since some of these species were also introduced from other countries and released in Hawaii it is not known exactly how many of them were from Malayan stocks. However, *O. longicaudatus* var. *malaiensis* shipped from Malaya and released in 1948 was recovered the same year. *O. oophilus* and *O. vandenboschi* were also recovered in 1948 but it is uncertain whether establishment was from Philippines or Malayan stocks, though the latter source is the more probable. Earlie in 1935–36 F. C. Hadden had shipped six species of fruit-fly parasites, including three *Opiu* spp., from Malaya, India and Ceylon to Hawaii but these did not become established (Hadden 1936; Clausen *et al.*, 1965).

NEW CALEDONIA

From 25 shipments of puparia of fruit-flies sent to Hawaii the following parasites were reared: *O. l. novacaledonicus*, *O. fijiensis* Full., *O. froggatti* Full. var. ?, *S. endius* and *Pseudeucoila* sp. (Clausen *et al.*, 1965).

PHILIPPINES

Clausen *et al.* (1965) mention a number of fruit-fly parasites obtained from material sent from the Philippines to Hawaii. In the material received from Luzon in 1947 the so-called *O. persulcatus* was the prominent parasite of *D. dorsalis*. These were later found to be a mixture of *O. oophilus* and *O. vandenboschi*. From this shipment *O. longicaudatus* var. *chocki*, *O. incisi* and *A. indicum* were also reared. Other parasites were *Opius skinneri* Full., *O. fletcheri* var. ?, *O. makii* Sonan, *Spalangia* sp., *Psilus* sp., *P. vindemmiae* and an Encyrtid. The predacious Staphylinid beetle *Thyreocephalus albertisi* (Fauvel) was propagated and released in Hawaii for several years (Clausen *et al.*, 1965).

TAIWAN

Puparia of *D. dorsalis* were sent to Hawaii in 1949–50, from which *Opius formosanus* *O. arisanus* Sonan Complex, *O. makii*, *Tachinaephagus* sp., *Spalangia* sp. and *P. vindemmiae*, were obtained. In addition, two consignments of a parasitic mite, *Tyroglyphus* sp., which attacks fruit-fly larvae and pupae in soil, were also sent to Hawaii (Clausen *et al.*, 1965).

(34) ***Phytomyza*** sp.

PAKISTAN

In 1969, *Diglyphus* sp., *Chrysocharis* sp. (Hym., Eulophidae) and an *Opius* sp. were shipped to New Zealand by the CIBC, Pakistan Station. These were directly released in the field to control leaf-miners.

(35) **Rice and sugarcane borers**

CEYLON

In 1939, Mauritius introduced the following parasites from Ceylon to control the sugarcane borer *Chilo sacchariphagus*: *Trichospilus pupivora* (18,000 adults), *Bracon chinensis* (= *B. albolineatus* Cam.) (200 adults), *Trichogramma evanescens* (5,000 adults) (see footnote on page 22) and *Xanthopimpla stemmator* Thnb. (47 adults). The first two species were mass-bred and 275,000 of the former and 2,500 of the latter were released in various localities. *Trichogramma* was also bred on a large scale and over 1½ million parasites were liberated during 1939–41. *X. stemmator* was the only parasite established. It was abundant in the field in 1940 but became scarce in 1941 and 1942. Only 16 males and 13 females had been released in 1939 and recoveries were made five months later. In 1952, parasitism was only 3·2%, *X. stemmator* also parasitised the pupae of *Sesamia calamistis* Hmps. From Mauritius the species was established on Reunion Island in 1953 (Moutia and Mamet, 1946; Vinson, 1924; Moutia and Courtois, 1952; Jepson, 1954; Williams, 1954).

INDIA

Over the past 10 years or so a very large number of species of parasites of graminaceous borers have been shipped from India by the CIBC Station there to various parts of the world, These are listed below, with whatever information is available to date regarding recoveries and establishment of some of the introduced parasites. For additional information on these the reader is referred to Part I of this *Review*.

To the U.S.A.

Between 1963 and 1966 the following were shipped for trial against *Diatraea*: *Apanteles flavipes* Cameron (Braconidae), *Bracon chinensis*, *Campyloneurus mutator* F. (Braconidae) *Centeterus alternecoloratus* ? var., *Goniozus indicus*, *Iphiaulax* sp. (Braconidae), *Rhaconotus* sp. nr. *signipennis* (Braconidae), *Stenobracon deesae* Cam., *S. nicevillei* Bingh., *Trichospilus diatraeae* and *Sturmiopsis inferens*. In 1966 *Apanteles chilonis* (Japanese origin) was also sent. Over 28,000 adults of *A. flavipes* reared on *D. saccharalis* (F.) were released in sugar-cane fields in Florida during May-October, 1963. A few specimens were recovered four months after release but none was reared from larvae collected in April-November, 1964 (Gifford and Mann, 1967). However, the latest available information indicates that it is now well-established in Florida.

In 1954, *Apanteles angaleti*, *Bracon brevicornis*, *Chelonus heliopae* Gupta and *Chelonus narayani* Subba Rao which parasitise various Lepidoptera in India, had been shipped to the U.S.A. and released against *D. saccharalis* near Houma (Louisiana) but failed to become established (Subba Rao, 1955; Charpentier, 1956).

To Mexico

A. flavipes, *B. chinensis*, *Elasmus zehntneri* Ferr., *Goniozus indicus*, *Rhaconotus scirpophagae*, *T. diatraeae* and *S. inferens* were shipped in 1960 but no releases of any of these were made.

To the West Indies

Between 1958 and 1963 several parasite species were shipped from India. These included: *B. chinensis*, *B. hebetor*, *C. mutator*, *G. indicus*, *Iphiaulax* sp., *Isotima javensis*, *R. scirpophagae*, *Tropobracon schoenobii* Vier. (?), *Tetrastichus ayyari*, *T. israeli*, *Trichogramma australicum*, *T. japonicum* (from cultures originating from Taiwan and the Philippines, respectively), *Trichospilus diatraeae*, *E. zehntneri* and *S. inferens*. *T. japonicum* was bred in Trinidad and shipped to Montserrat. *S. inferens* was also bred and liberated in the field but was not found to be very promising. Bennett (1965) has discussed the results of laboratory trials with several of these parasite species on *Diatraea* and allied genera in Trinidad.

To Mauritius

From 1958 to 1966 the following species were sent: *B. chinensis*, *B. hebetor*, *E. zehntneri*, *Goniozus* sp., *G. indicus*, *Iphiaulax* sp., *I. javensis*, *R.* sp. nr. *signipennis*, *R. scirpophagae*, *S. deesae*, *S. nicevillei*, *T. schoenobii*, *Tropobracon indicus* Ramak., *T. israeli*, *T. japonicum*, *T. australicum*, *T. diatraeae*, *Xanthopimpla* sp. and *S. inferens*. According to Williams and Mamet (1962) and Greathead (1971) *E. zehntneri*, *R. scirpophagae*, *T. israeli*, *S. deesae*, *S. nicevillei*, *Goniozus* sp. (*indicus*), *Iphiaulax* sp., *I. javensis*, *S. inferens* and *T. diatraeae* were released. The last named has been recovered in 1969 but the others apparently failed to become established.

To Barbados

I. javensis and *T. diatraeae* were shipped in 1963. The former could not be bred there while the latter parasitised the Tachinid *Lixophaga diatreaeae* in the laboratory. Therefore no releases were made. In 1966 and 1967 *Apanteles chilonis*, *A. flavipes*, *B. chinensis*, *C. mutator*, *R. signipennis*, *S. inferens*, *T. australicum*, *T. japonicum* and *T. fasciatum* (obtained from Florida) were sent to Barbados.

A. flavipes was liberated in July 1966. By the end of 1967 it was parasitising some 50% of the *Diatraea* larvae in a 5-square-mile area around the release site. In September, 1968 levels of parasitism in 22 fields varied from 2·2 to 89·9% with an average of 26%. The parasite has now spread over the entire island and given outstanding economic control of the sugarcane borer.

A. chilonis, *R. signipennis* and the *Trichogramma* spp. were also released in 1966 but no recoveries have been made so far.

In 1968 *A. flavipes* has subsequently been sent from the West Indian Station, CIBC, to Peru and the Bahamas—in the latter it has been recovered in the field.

To Malagasy

S. deesae and *S. nicevillei* were sent to Malagasy in 1965 and bred on *Sesamia calamistis*. Releases were made in 1966 and a survey made later gave no evidence of establishment. In 1969 *A. chilonis* and *B. chinensis* were also sent for trial against the white borer of rice, *Maliarpha separatella* Ragonot (Lep., Pyralidae). Observations are in progress (Appert *et al.*, 1969).

To the Philippines

In 1966, 1968 and 1969 *S. inferens* and in 1969 *A. flavipes*, *Pediobius furvus* (Eulophidae) (origin East Africa), *Macrocentrus turkestanicus* Telenga (Braconidae) and *T. fasciatum* were sent to the Philippines for trial against rice stem-borers.

To Japan

During 1965–68 *B. chinensis* and *A. flavipes* were sent for trial against rice stem-borers but no field releases have yet been made.

To Pakistan

In 1967 *A. chilonis*, *A. flavipes* and *A. sesamiae* (origin East Africa) were sent to the CIBC Pakistan Station.

To Taiwan

In recent years a number of parasites have been sent to Taiwan for trial against sugarcane borers. These are: *T. fasciatum* (Barbados and Florida strains), *G. indicus*, *Goniozus* sp., *B. hebetor*, *T. diatraeae*, *R. scirpophagae*, *R.* sp. nr. *signipennis*, *I. javensis* and *S. inferens.*

INDONESIA

In 1961 a series of shipments of field-collected puparia of the Tachinid *Diatraeophaga striatalis* were sent by Dr. M. A. Ghani from Java to Mauritius and the CIBC, Indian and West Indian Stations. Difficulty in securing mated females limited the laboratory tests with this species (Ghani, 1962; Ghani and Williams, 1963). However, before stocks were lost sufficient tests were undertaken to determine that *Diatraea saccharalis*, *D. impersonatella* (Wlk.) and *D. lineolata* (Wlk.) were satisfactory hosts, whereas *D. centrella* (Mosch.) was not (Bennett, 1965).

As a result of later attempts by the French Research Institute for Tropical Agriculture, 4,812 adults of *D. striatalis* were sent to Malagasy in 1965 and from this lot 1,470 flies were released on Reunion Island and 530 in Malagasy. *D. striatalis* was also bred in the laboratory and released in 1965 on both islands. The first recoveries were made on Reunion in 1968 but attempts to recover the parasite in Madagascar have failed. The failure of this Tachinid in Madagascar is due to a sudden increase in parasitism of the borers by *A. flavipes*, introduced from Mauritius in 1961, as a result of which the borer population had greatly declined when *Diatraeophaga* was released (Breniere *et al.*, 1966 *a* and *b*; Appert *et al.*, 1969).

D. striatalis was introduced from Indonesia into Mauritius for trial against *Chilo sacchariphagus* in 1961 but it was not established (Ghani and Williams, 1963). This parasite was again obtained from Reunion Island in 1966 and mass-bred in the laboratory. Approximately 30,000 mated females were released during 1966–68. Parasites emerged from hosts collected from one release site 16 days after the last liberation indicating that the species had bred in the field. However, no other recoveries were made but it was considered premature to come to any conclusion regarding the establishment of the parasite (Williams, 1966, 1967; J. R. Williams, pers. com.).

D. striatalis was introduced into Taiwan in 1916 to control *Chilo venosatus* but failed to become established (Ishida, 1927; Takano, 1940).

PAKISTAN

To East Africa

A. flavipes was sent to the CIBC, East African Station in 1967. A laboratory culture was established and releases were made against *Chilo partellus* in 1968. Some cocoons were recovered from Kawanda (Uganda) indicating that the parasite was at least temporarily established.

(36) **European corn-borer**—*Ostrinia furnacalis* (Guen.)

PHILIPPINES

Perezia pyraustae Pail, a protozoan disease (of European origin) of the European corn borer larva, was sent to Indonesia. Hundreds of egg clusters and larvae of both sugarcane and rice stem-borers were inoculated in the field with this material. There is no evidence of establishment (Dresner, 1958).

(37) ***Ostrinia kasmirica*** **Moore**

INDIA

Bracon brevicornis, *Coccygomimus laethoe* (Cam.) (= *Pimpla poesia* Cam.), *C. turionellae*. (L.), and *Scambus* sp. (Ichneumonidae) reared from *O. kasmirica* Moore were sent to the U.S.A. during 1964–66 for trials against *Ostrinia nubilalis*. The parasites have not been released pending further studies on their biologies and host relationships in India.

(38) **Pink boll-worm**—*Platyedra gossypiella* (Saund.)

INDIA

Attempts to introduce *Bracon greeni* from India into the U.S.A. between 1952 and 1957 to control *P. gossypiella* failed, possibly because of the difficulty in breeding it in the laboratory. However, in laboratory tests the parasite successfully attacked and developed in the larvae of the boll weevil *Anthonomus grandis* Boh. No field liberations were made (Angalet, 1965).

Adults of *Bracon lefroyi* Dudg. & Gough were sent to Egypt against boll-worms but the parasite did not become established (Husain and Mathur, 1924).

In 1953–55 *Apanteles angaleti*, *Bracon brevicornis*, *B. gelechiae*, *Chelonus heliopae* and *C. narayani* were introduced from India into the U.S.A. and Mexico and released against *P. gossypiella*. No recoveries were made from 85,000 bolls collected subsequently at 170 liberation sites, mainly in the Rio Grande Valley (McGough and Noble, 1955 and 1957).

Apanteles sp., *Brachycoryphus nursei* Cam., *B. greeni* and *Rogas* sp. were shipped to Trinidad and the first three also to Antigua during 1961–63. Field liberations were made in Antigua but there has been no recovery.

PAKISTAN

In 1961 larvae of *Earias* sp. parasitised by *Rogas* sp. were shipped from the CIBC, Pakistan Station to the West Indian Station, for trial against pink boll-worms. Since it did not parasitise the pink boll-worm under laboratory conditions at Trinidad it was not released.

(39) ***Heliothis*** **spp.**

INDIA

The following natural enemies were sent by the CIBC, Indian Station to the U.S.A. during 1963–68 for trial against *Heliothis zea* (Boddie): *Ecphoropsis perdistinctus*, *Eriborus* sp., *Enico-*

spilus sp. (Ichneumonidae), *Microgaster* sp. nr. *pallidipes* Szep. (Braconidae), *Drino* sp., *Drino imberbis* Wied., *Eucarcelia ceylonica* T.T., *E. illota* Curran, *Exorista fallax* Mg. and *Goniophthalmus halli* Mesnil (Tachinidae) and the Reduviid predator *Sycanus indagator* Stal. *E. perdistinctus* is already present in the U.S.A. under the name of *Campoletis perdistinctus* Vier. (Achan *et al.*, 1968). A comparative study of the American and the Indian populations of this species is being made in the U.S.A. to determine whether they exhibit any differences in behaviour and other characteristics. Cultures of some of the Tachinids have been built up but no field releases have as yet been made.

In 1965–68 *E. perdistinctus*, *Eriborus* sp., *D. imberbis*, *E. illota* and *S. indagator* were sent to Mauritius for trial against *Heliothis* spp. *E. perdistinctus* was found in the field on a number of occasions, but in small numbers, in many localities but it is now too early to state whether establishment is permanent.

In 1967–69 *E. illota*, *D. imberbis*, *E. perdistinctus*, *E. fallax*, *G. halli*, *Eriborus* sp. and *Eucelatoria* sp. (origin: U.S.A.) were sent to Barbados. *E. perdistinctus* was released against *Heliothis virescens* (F.) in the field but not recovered.

In 1969–70 *D. imberbis*, *E. illota*, *E. perdistinctus*, *G. halli* and *Eriborus* sp. were sent to Bolivia.

In 1969 *E. illota*, *D. imberbis*, *Eucelatoria* sp. and *E. perdistinctus* were shipped to New Zealand. Cultures of these parasites have been built up in the laboratory and field liberations have also been made (Dr. R. A. Cumber, pers. com.). Field recovery surveys are yet to be made.

(40) ***Spodoptera litura* (L.)** (= *Prodenia litura* L.)

INDIA

In 1969 *Telenomus remus* Nixon (origin New Guinea) and *Trichospilus pupivora* were sent to Israel for field trials.

In 1966 and 1967 *T. remus* was sent to Cyprus.

Results of these introductions are not known.

(41) **Potato tuber moth**—*Phthorimaea operculella* (Zeller)

INDIA

Cultures of seven species of parasites (of American origin) of this cosmopolitan pest were transferred to the CIBC, Indian Station, in 1964 and 1965 following the closure of the Californian Station. Three other species were later obtained from South Africa and Cyprus. All these have been shipped to other countries.

Microchelonus curvimaculatus Cam. (Braconidae), *Pristomerus vulnerator* Panzer (Ichneumonidae), *Diadegma surendrai* Gupta and *Bracon gelechiae* which parasitise the potato tuber moth in India have been sent to Cyprus together with all the other PTM parasites introduced from South and North America and also South Africa.

In connection with a campaign against the PTM organised by CIBC at the request of the Department of Agriculture, Cyprus, a large number of parasites were released and the majority of them have been recovered in the field. In 1966 *Apanteles subandinus*, *Copidosoma koehleri* (later identified as *Copidosoma uruguayensis* Tach.) and *Orgilus lepidus* and in 1967–68, in addition to these species, *C. haywardi*, *O. parcus*, *M. curvimaculatus*, *B. gelechiae* and *Temelucha* sp. have been recovered. In 1968 the situation appeared to be that whilst these were still present they occurred only in very low numbers, with the exception of *M. curvimaculatus* (from India) and *A. subandinus* (from South America) which appeared to be well-established. Further work is envisaged to check on the situation, since it would certainly appear that whilst, with the temporary establishment and abundance in some areas of a number of parasites, biological control appears promising, the very widespread, frequent and heavy application of chemical insecticides obviously militates against a build-up of parasite populations. The value of the natural enemies established in Cyprus can be assessed if experimental areas where insecticides are not used are arranged.

The liberation of exotic parasites was suspended during 1969. Evaluation of the introduced parasites was made in the autumn crop. The pest was hardly found either in sprayed or unsprayed fields. No exotic parasite was recovered. The indigenous parasites also were extremely scarce. It is to be ascertained whether the absence of the pest was due to the beneficial activity of the parasites or to other factors.

Shipments of PTM parasites have been sent to other areas as follows:—

To Australia, *A. scutellaris*, *A. subandinus*, *Agathis unicolor*, *O. lepidus*, *Temelucha* sp., *C. haywardi*; to Bermuda, *A. subandinus*, *C. uruguayensis*, *M. curvimaculatus*, *Temelucha* sp., *O. lepidus*, *O. parcus*, *Diadegma raoi* Gupta (from Cyprus), *D. stellenboschense*; to New Zealand, *C. uruguayensis*, *O. lepidus*, *O. parcus*, *A. subandinus*, *A. scutellaris*, *A. unicolor*, *Temelucha* sp., *D. raoi*, *D. stellenboschense*, *D. surendrai* (of Indian origin), *B. gelechiae*, *C. haywardi*, *M. curvimaculatus*; to Mauritius, *A. subandinus*, *C. haywardi*, *C. uruguayensis*, *O. lepidus*; to the U.S.A., *D. stellenboschense*, *M. curvimaculatus*, *D. raoi*, *O. parcus*; to Japan, *C. uruguayensis*; to Malagasy, *A. scutellaris*, *A. subandinus* and *C. haywardi*; To Tanzania, *A. subandinus*, *C. uruguayensis*, *C. haywardi*, *D. raoi* and *O. lepidus*; to Kenya, *C. uruguayensis*; to Zambia, *O. lepidus*; and to South Africa, *A. subandinus*, *C. haywardi*, *C. uruguayensis* and *O. lepidus*.

All the parasites sent to Australia were mass-bred and released. *C. uruguayensis*, *A. subandinus* and *O. lepidus* are widely established on *P. operculella* in eastern Australia. Parasitism averaged 57% in twelve potato-growing districts sampled in April 1970 and exceeded 70% in three of them. In some coastal areas of New South Wales total parasitism may exceed 60%, attributable mainly to *O. lepidus* and *A. subandinus*. Quantitative evaluation of parasitism in the field strongly suggests that the introduced parasites of PTM that are established have in fact become a major mortality factor in the population dynamics of the pest. *A. subandinus* has proved to be the most successful species. It is well adapted to cool temperature areas while *O. lepidus* and *C. uruguayensis* are better adapted to warm subtropical areas. *O. lepidus* is well adapted to warm, coastal, frost-free environments (D. F. Waterhouse and E. McC. Callan, pers. com.). In Mauritius, *Copidosoma* was found heavily parasitising *P. operculella* in two localities in Black River in the southern districts of the Island. In New Zealand *O. parcus* and *A. subandinus* have been recovered in early 1970 probably from the progeny of parasites released late in 1969. *A. subandinus* and *C. uruguayensis* have become established in South Africa. In Mauritius heavy parasitism by *C. uruguayensis* was reported at two localities in 1966 but whether this establishment is permanent remains to be confirmed (Greathead, 1971). It is not as yet known whether the parasites released have become established in other countries.

(42) **Diamond-back moth**—*Plutella xylostella* (L.)

INDIA

Nucleus cultures of *Apanteles plutellae*, *Thyraeella collaris* and *Brachymeria* sp. were sent to Thailand in 1965 for trial against *P. xylostella*. Attempts to breed the species there failed and none could be released in the field. In 1968 *A. plutellae*, *Macromalon orientale*, *T. collaris* and *Tetrastichus sokolowskii* were sent to Barbados and Thailand. All the four species have been released in Barbados and initial recoveries of *A. plutellae* and *T. collaris* have been made.

In 1968 *A. plutellae*, *M. orientale*, *Nythobia* sp., *T. sokolowskii* and *T. collaris* were sent to Hong Kong.

In 1965 *T. collaris* was sent to Ceylon.

A culture of a nuclear polyhedral virus of *P. xylostella* has recently been sent to Zambia and the CIBC, West Indian Station for field trials.

(43) **Coconut caterpillar**—*Nephantis serinopa* Meyr.

INDIA

Several species of parasites attack this pest in India and Ceylon. Some of these have been exchanged between these two countries and these are listed in Part I of this *Review*.

(44) **Small leaf-moth of coconut**—*Levuana iridescens* B.B.

MALAYSIA

The parasitic fly *Ptychomyia remota* shipped from Malaya to Fiji in 1925 against *L. iridescens* gave spectacular control of the leaf-moth. *Callimerus arcufer*, also introduced in the same year, failed to become established (Tothill *et al.*, 1930).

(45) **Coconut flat moth**—*Agonoxena argaula* Meyr.

SAMOA

A shipment of *Agonoxena* parasitised by *Apanteles agonoxenae* Full. and *Brachymeria agonoxenae* Full. was sent to Hawaii in 1948. The latter was multiplied in the laboratory but only 11 adults were released at Kaalawai, Honolulu. The parasite has not been recovered (Van Zwaluwenburg, 1949).

(46) *Tiracola plagiata* Walker

INDIA

Attempts to introduce the Tachinid parasite *Sturmia* (*Drino*) *inconspicuoides* Meig. from India into the Territory of Papua and New Guinea in 1961 were unsuccessful. In 1965–66 *Apanteles* sp. (*ultor* group) was successfully shipped and some releases were made. However, there have been no recoveries.

(47) *Achaea janata* L.

Microplitis maculipennis Szep. (Braconidae) and a *Telenomus* sp. (Scelionidae) parasitising the larvae and eggs of *A. janata*, respectively, were sent to the Territory of Papua and New Guinea in 1965–66. Both were released but no recoveries have been made. *Trichogramma australicum* and another *Trichogramma* sp. which was then thought to be *T. semifumatum* Perkins were also shipped, since these were believed not to occur there. Later both these species were reported to exist in the Territory. However, in a recent comprehensive biosystematic study of *Trichogramma* at the CIBC, Indian Station, the species parasitising the eggs of *A. janata* in India was found to be a new one and it has since been described by Nagaraja and Nagarkatti (1969) as *T. achaeae*.

(48) *Lymantria obfuscata* Wlk.

INDIA

During 1967–68 *Drino discreta* Wulp., *D. inconspicuoides* Baranov, *Exorista rossica* Mesnil (Tachinidae), *Rogas* sp. and *Anastatus* sp., all of which attack *Lymantria obfuscata*, were sent to the U.S.A. for laboratory breeding and field releases against *Porthetria dispar* (L.). *E. rossica* and *Rogas* sp. have been released. Further releases of these and other parasites are expected to be made.

(49) Meliaceous shoot borers—*Hypsipyla* spp.

INDIA

During 1967–68 *Apanteles* sp. ? *puera* Wilkn., *Apanteles* sp., *A. leptoura* Cam., *A.* sp. (*vitripennis* group), *Afrephialtes latiannulatus* Cam. (Ichneumonidae), *Antrocephalus renalis* Wtrst. and *Tetrastichus spirabilis* Wtrst. (Eulophidae) were sent to the CIBC, West Indian Station for laboratory trials against *H. ferrealis* (Hmps.) and *H. grandella* (Zell.)

(50) Wood wasps—*Sirex* spp.

INDIA AND PAKISTAN

Rhyssa persuasoria himalayensis Wilkinson (Ichneumonidae) was sent during 1963–65 to Australia and New Zealand to control *S. noctilio* F. There was limited success in getting the parasite in phase with the season of Siricids in Australia. In 1967 a five-fold increase in breeding the species was obtained in New Zealand and liberations have been made in Nasebt and Herbert Forests.

(51) **European pine saw-fly**—*Neodiprion sertifer* (Geoff.) (Hym., Diprionidae)

PAKISTAN

In 1967 *Olesicampe* sp. and *Agrothereutes* sp. were sent to the CIBC, European Station, for trial against *N. sertifer*. It was thought that since these appeared useful they might be of value in Canada. *Agrothereutes* sp. bred easily but was considered to be inferior to some of the more effective European parasites. *Olesicampe* was not tested since host larvae were no available at that time.

(52) **Giant African snail**—*Achatina fulica* Bowdich

In 1954 the Lampyrid *Lamprophorus tenebrosus* was introduced from the Peradeniya area in Ceylon into Hawaii against the giant African snail *Achatina fulica*, but no recovery was made (Davis and Butler, 1964). Davis (1959) refers to its introduction again from Kandy in 1958 and release on Oahu and Maui. This was also introduced into Indonesia and Guam (Bess, 1956). None of these introductions was successful.

Between 1956 and 1958 twelve shipments of *L. tenebrosus* were sent to Mauritius from Ceylon. Several thousands of larvae were released. Some recoveries were made two months after the last release but later surveys failed to detect it (Greathead, 1971).

Davis and Butler (1964) have referred to the introduction of *Gulella bicolor* (Hutton) (Streptaxidae) from Malaysia, the Philippines, Saipan and the Mariana Islands into Hawaii in 1957. It was released but not recovered. This species was introduced again from the Philippines in 1957 and from Saipan and Malaysia in 1958 and released in Hawaii against *Subulina octona* (Bruguiere), a host of a liver-fluke of poultry (Davis, 1958, 1959).

(53) **Citrus red mite**—*Panonychus citri* (McG.)

INDIA

The predacious Phytoseiid mites *Typhlodromus aerialis* (Muma), *T.* (*Amblyseius*) *finlandicus* (Oudemans), *T. largoensis* (Muma) and *T. rickeri* (Chant) were sent to California in 1963. All were released in southern California. The major effort has been with *T. rickeri*, of which nearly half a million were released from 1961 to 1964. It is being recovered in small numbers in one of the release sites five years after the last releases but it has not materially reduced the pest mite populations (McMurtry, 1969).

(54) **Cockroaches**

NEW CALEDONIA

In 1940 a parasitic wasp *Ampulex compressa* attacking cockroaches in New Caledonia was sent to Hawaii where it was successfully bred and liberated. The wasp has become well-established and plays a significant role in controlling some species of cockroaches (Pemberton, 1948).

(55) **Horn-fly**—*Lyperosia irritans* (L.)

CEYLON

The Histerid *Pachylister lutarius* Erichson was introduced into Hawaii in 1958 for trial against horn-fly larvae and other dipterous livestock pests. It was recovered for the first time on Oahu in 1966 (Davis and Krauss, 1967). Davis (1959) had earlier referred to the introduction of this species along with *Hister javanicus* Paykull, *Pachylister chinensis* and *Santalus orientalis* Paykull and to their release on Oahu.

(56) **Mosquitoes**

INDIA

The annual fish *Nothobranchius guentheri* Pf. (native of Zanzibar and East Africa) was sent to the Bahamas for trial against mosquitoes. Results of its introduction are not known.

PHILIPPINES

In 1954 a predatory mosquito *Toxorhynchites splendens* was sent to Hawaii in an attempt to control the mosquitoes *Aedes albopictus* and *A. aegypti* (L.). Though established, its value as a control agent is doubtful (Pemberton, 1964).

(57) **Prickly pears**—*Opuntia* spp.

Dactylopius ceylonicus and *D. opuntiae* have been introduced into various countries to control prickly pears. The former was introduced into Queensland in 1903 and again in 1913 and 1914 from Ceylon and India, and into South Africa in 1913 from Ceylon. In Queensland it was liberated in 1914 and within a few years largely controlled *O. vulgaris*, the only prickly pear which it attacked (Wilson, 1960). In South Africa also it attacked only *O. vulgaris* and controlled it (Warren, 1914; Hutson, 1926). The same species was shipped to St. Helena in 1933 (Jepson, 1935). This introduction was a failure (A. S. Leask, pers. com.). *D. opuntiae* was introduced into Mauritius and India in 1926–27. In Mauritius it was bred on *O. tuna* from a single gravid female and was liberated throughout the island in 1928. By 1931 it had spread practically throughout the island and by 1946 the prickly pear was almost completely eradicated (Moutia and Mamet, 1946). In India it became established and gave good control of *O. dillenii* (see Part I).

(58) **Dodder**—*Cuscuta* spp.

PAKISTAN

In 1967–68 over 20,000 *Melanagromyza cuscutae* Hering (Dip., Agromyzidae) and *Smicronyx roridus* Mshl. were sent to Barbados. These were released against *Cuscuta americana* L. and *C. indecora* Choisy but no recoveries were made.

M. cuscutae and *S. roridus* were also sent to the Bahamas in 1966 and 1968, respectively. In neither case is the result of releases known as yet.

59) **Noogoora burr**—*Xanthium strumarium* L.

INDIA

The Cerambycid *Nupserha antennata* Gahan was introduced from India into Queensland, Australia, in 1963 to control Noogoora burr. Adults were liberated at two points in 1964 (Haseler, 1966). The insect is now well-established and its effects on Noogoora burr are being assessed (Simmonds, 1971).

PAKISTAN

Eublemma parva Hb. (Lep., Noctuidae) was shipped from CIBC, Pakistan Station, to the Division of Entomology, CSIRO, Australia, in 1960. It was later found that the species was already present in Queensland (Simmonds, 1964).

(60) **Nutgrass**—*Cyperus rotundus* L.

PHILIPPINES

In 1922 and 1925 *Bactra* (*Chiloides*) *venosana* (Zeller) (= *Bactra truculenta* Meyr.) (Lep., Tortricidae) and *Athesapeuta cyperi* Mshl. (Col., Curculionidae) were sent to Hawaii to control nutgrass. Both became established and spread to several islands but neither species proved to be of much value in controlling the weed. *Bactra* is severely restricted by native parasites (Baltazar, 1963; Poinar, 1964).

(61) **Indian rhododendron**—*Melastoma malabathricum* L.

MALAYSIA AND SINGAPORE

In 1965 the Arctiid *Selca brunella* Hampson was introduced from Kuala Lumpur and Singapore into Hawaii to control the Indian rhododendron, a serious weed of pasture grasslands. The insect became established and has caused much dieback of the weed, resulting in inhibition of flowering and fruiting in some localities. A Pyraustid leaf-roller, *Bocchoris adipalis* Zeller, which was also introduced from Malaysia has not as yet been recovered (Davis and Krauss, 1966 and 1967).

PHILIPPINES

In 1957 larvae of the Pyraustid leaf-roller *Bocchoris fatualis* (Lederer) were shipped to Hawaii in an attempt to control *M. malabathricum*. They were released in the following year in a number of localities on the islands of Kauai and Hawaii. The leaf-roller was found to be established in one locality on Kauai but it did not prove effective in controlling the weed (Davis, 1959, 1960; Davis and Krauss, 1965).

(62) ***Ludwigia octovalvis* (Jacq.) Raven**

In 1965 *Haltica caerulea* (Oliv.) (Col., Halticidae) was shipped to Mauritius by the CIBC, Indian Station, for tests against *L. octovalvis* in quarantine. It was reported to feed on seedling tobacco under local conditions and so the culture was terminated. Following this report larvae and adults of *H. caerulea* were again subjected to repeated tests on some fifteen commercial varieties of tobacco (*Nicotiana tabacum*) at Bangalore, which confirmed that the insect is not harmful to tobacco and is incapable of breeding on it.

Table I. *Natural enemies introduced from the Fiji Islands into other countries*

Natural enemy 1	Year of introduction 2	Introduced into 3	To control 4	Remarks 5	References 6
Spalangia cameroni Perk.	1933	Solomon Is.	*Lyperosia exigua* (de Meij.)	Not established	Lever, 1937; Pagden, 1934
Pchylister chinensis Quens.	1944–46	Australia	,,	Established after the second introduction but still confined to the original liberation site	Wilson, 1960; Bornemissza, 1968
,,	1952	New Hebrides, New Britain and Palau Is.	House-fly	Established in New Hebrides and New Britain	O'Connor, 1958; Anon, 1959; Bornemissza, 1968
,,	1959	Cocos (Keeling) Is.	,,	Not established	,,
,,	1939	Solomon Is.	,,	Established	Simmonds, 1940 *a*; Anon, 1959; Bornemissza, 1968
,,	1948	Barbados, Guyana and Trinidad	,,	Not established	Bornemissza, 1968
,,	1950	Mauritius	,,	,,	,,
,,	1951	Hawaii	,,	,,	,,
,,	1952	Pupua and New Guinea	*Oryctes rhinoceros* (L.)	,,	Dun, 1954, 1955
Teleonemia scrupulosa Stal.	1935, 1937, 1958	New Hebrides	*Lantana camara* L.	Results not known	Simmonds, 1935 *b*; Lever, 1938 *d*; Anon, 1959
,,	1935, 1937	New Caledonia	,,	Established; has helped in limiting the spread of *Lantana*	Simmonds, 1935 *b*; Lever, 1938 *d*; Szent-Ivany, 1964
,,	1936, 1940	Western Samoa	,,	Results not known	Simmonds, 1937 *a*; Lever, 1941 *a*
,,	1935, 1936	Australia	,,	Established; has helped in control	Veitch, 1941; Wilson, 1960
,,	1937, 1939	Tonga Is.	,,	Established, but was of little control value, better by 1970	Lever, 1938 *c*, *d*, 1939 *c*; Cottrell-Dormer, 1941; Simmonds, 1971
Uroplata girardi Pic.	1969	,,	,,	Too early to evaluate the results	Simmonds, 1971
Ophiomyia lantanae (Frogg.)	1917	Australia	,,	Established	Wilson, 1960
Liothrips urichi Karny	1938, 1939	Solomon Is.	*Clidemia hirta* (L.) D. Don	Introduction unsuccessful	Lever, 1938 *a*, *c*; 1940

TABLE I—(*Contd.*)

1	2	3	4	5	6
Plaesius javanus **Er.**	1937, 1938	Jamaica	*Cosmopolites sordidus* (Germ.)	Established, unable to control the pest	Edwards, 1938, 1939, 1940, 1942; Leach, 1958
,,	1937	Tahiti	,,	Established, reduced the damage caused by the weevil	Lever, 1938 *c*
,,	,,	Cook Is.	,,	Established but no effective control	Lever, 1938 *d*
,,	,,	Society Is.	,,	Established	Hoyt, 1957
,,	1942	Puerto Rico	,,	Results not known	Lever, 1943 *c*
,,	1942–43	Honduras	,,	,,	Annand, 1944
,,	1947	Guam	,,	Established	Gardner, 1958
,,	1934	Australia	,,	Not established	Wilson, 1960
,,	1949	New Caledonia	,,	Established	Hoyt, 1957
,,	1952	Tonga Is.	,,	Results not known	,,
,,	..	Taiwan	,,	,,	Miwa, 1938
Tetrastichus giffardianus Silv.	1935–36	Australia, Loyalty Islands, New Caledonia	*Ceratitis capitata* (Wied.) and *Strumeta tryoni* (Frogg.) in Australia; *Dacus* spp. in other areas	Results not known	Simmonds, 1935 *b*; Hoyt, 1957; Wilson, 1960
,,	1937, 1938	Cook Is.	*Dacus* spp.	,,	Lever, 1938 *c*
,,	1935, 1937, 1938	Western Samoa	,,	,,	Simmonds, 1935 *b*; Lever 1938 *c*
Dirhinus (?) *giffardii* Silv.	1937, 1938	Western Samoa, Cook Is.	,,	,,	Lever, 1938 *c*; Hoyt, 1957
Aceratoneuromyia indicum (Silv.)	,, ,,	,,	,,	Established in Samoa	,,
,,	1938	Hawaii	,,	Not established	Weber, 1951; Lever, 1938 *c*
Cryptognatha nodiceps Mshl.	?	Guam	*Aspidiotus destructor* Sign.	Results not known	Anon, 1959
,,	?	Tahiti	,,	,,	,,
,,	1937, 1938	Hawaii	*Pinnaspis buxi* Bch.	,,	Lever, 1938 *c*, 1939 *a*
Pediobius parvulus (Ferr.)	1938	New Britain	*Promecotheca papuana* (Csiki)	Established. Effective control achieved	Wilson, 1960; Gressitt, 1958, 1959; Froggatt, 1939; O'Connor, 1940 *a*
,,	,,	Tonga Is.	*P. coeruleipennis* Blanchard	Not established	Lever, 1939 *b*; O'Connor, 1949
,,	,,	Western Samoa	,,	Established	Lever, 1939 *a*; Hoyt, 1957
Bufo marinus L.	1939	Gilbert and Ellis Is.	Various pests	Results not known	Lever, 1940
,,	1940	Solomon Is.	,,	Established	Lever, 1942 *c*
,,	1953	Samoa	,,	,,	Hoyt, 1957

Apanteles ruficrus Hal.	1939, 1940	Hawaii
Ootetrastichus beatus Perk. (Hym., Eulophidae)	1905	,,
Haplogonatopus vitiensis Perk. (Hym., Dryinidae)	,,	,,
Paranagrus perforator Perk. (Hym., Mymaridae)	,,	,,
Tytthus (= *Cyrtorhinus*) *mundulus* (Bredd.) (also from Australia)	1920	,,
Tetraeuaresta obscuriventris (Lw.)	1961	,,
Litomastix sp. (Hym., Encyrtidae)	1958	,,
,,	,,	Eastern and Western Samoa
Coelophora atrolineata Fairmaire (Col., Coccinellidae)	1960	Hawaii
Archaioneda tricolor Crotch. (Coccinellidae)	,,	,,
,,	1899	Samoa
Asolcus basalis Woll.	1952	Pitcairn Is.
,,	?	Guam
,,	1953	Samoa
,,	1942–43	New Caledonia
,,	1941	Tonga Is.
Apanteles agonoxenae Fullaway	1956	Hawaii
Bracon sp.	,,	,,
Telenomus nawaii Ashm.	1936	Egypt

Heliothis sp.	Not established	Lever, 1940, 1941 *b*; Fullaway, 1952
Perkinsiella saccharicida Kirk.	Established; gave considerable control on many plantations	Swezey, 1925, 1936; Pemberton, 1964
,,	,,	,,
,,	Established	Swezey, 1936; Zimmerman, 1948
,,	Well established; effectively controlled the leafhopper. It also fed on the eggs of *Peregrinus maidis*	Swezey, 1925, 1936; Clausen, 1951; Pemberton, 1964
Elephantopus mollis (Kuntl.)	Established very quickly and built up high populations in 1963	Davis and Krauss, 1962, 1964
Hedylepta accepta (Butl.) (Lep., Pyralidae)	Results not known	Davis, 1959
?	,,	O'Connor, 1958
Coccus viridis (Green)	,,	Davis, 1961
,,	,,	,,
Aphids	,,	Hoyt, 1957
Nezara viridula L.	,,	O'Connor, 1956; Hoyt, 1957
,,	,,	Anon, 1959
,,	,,	Hoyt, 1957
,,	Established	,,
,,	Established and gave good control	Hoyt, 1957; O'Connor, 1949
Agonoxena argaula Meyr.	Results not known	O'Connor, 1956
,,	,,	,,
Spodoptera litura (F.)	Proved very effective in controlling *Spodoptera*	Kamal, 1951 *b*

TABLE I—(*Contd.*)

1	2	3	4	5	6
Apanteles tirathabae Wlkn.	1935	Western Samoa	*Tirathaba complexa* Btlr.	Results not known	Simmonds, 1935 *b*
Nemeritis palmaris Wilk.	,,	,,	,,	,,	,,
Anisorcus affinis Crotch (Coccinellidae)	1899	Hawaii	Scale insects	Not established	Swezey, 1925
,,	,,	Samoa	*Lepidosaphes beckii* (Newm.)	Results not known	Hoyt, 1957
Verania lineola (Fab.) (Coccinellidae)	1904, 1906	Hawaii	Aphids and leaf hoppers	Not established	Swezey, 1925
Stylopid	1905	,,	Leaf hopper	,,	,,
Rhabditis spp. (Nemat., Rhabditidae)	1958	American Samoa	*Oryctes rhinoceros* (L.)	Results not known	O'Connor, 1958
,,		Seychelles	,,	,,	,,
Tytthus (*Cyrtorhinus*) *lividipennis* (Reut.)	?	Jamaica	?	,,	Anon, 1959
Cremastus sp.	1933	Samoa	*Nacoleia octasema* (Meyr.)	Results not known	Hoyt, 1957
Apanteles marginiventris Cress.	1952	Tonga Is.	Armyworms	,,	,,
Thyraeella collaris (Grav.)	1943	,,	*Plutella xylostella* (L.)	,,	,,
Rodolia cardinalis Muls.	1953	Gilbert Islands	*Icerya aegyptiaca* Dougl.	,,	,,
,,	1953	Samoa	*Icerya seychellarum* Westw.	Established	,,

TABLE II. *Natural enemies introduced from Indonesia into other countries*

Natural enemy 1	Year of introduction 2	Introduced into 3	To control 4	Remarks 5	References 6
Cremastus sp.	1933	Fiji	*Nacoleia octasema* (Meyr.)	Results not known	Taylor, 1933
Plaesius javanus Er.	1913, 1918	,,	*Cosmopolites sordidus* (Germ.)	Established and exercised partial control	O'Connor, 1950 *b*; Pemberton, 1954
,,	1934, 1935	Uganda	,,	Not established	Darling, 1946
,,	1921–24, 1926, 1929	Australia	,,	,,	Wilson, 1960
Chrysopilus ferruginosus Wied. (Dip., Leptidae)	1928	,,	,,	,,	,,
Pachylister chinensis Quens.	1938	Fiji	House-flies	Established but of doubtful control value	O'Connor, 1950 *b*; Simmonds, 1958; Bornemissza, 1968
,,	,,	Western Samoa	,,	,,	,,
Macrocentrus sp.	1960	Fiji	*Agonoxena argaula* Meyr.	Established	Hinckley, 1963 *a*
Pediobius parvulus (Ferr.)	1933	,,	*Promecotheca coeruleipennis* Blanchard	Introduction successful; complete control achieved	Taylor, 1937; O'Connor, 1950 *b*
,,	1937	New Hebrides	*Promecotheca opacicollis* Gestro	Established and completely controlled the pest	Lever, 1938 *b*; Cohic, 1953; Gressitt, 1958, 1959
,,	1938	New Britain	*Promecotheca papuana* (Csiki)	Established	O'Connor, 1940 *a*; Gressitt, 1958
Dimmockia javanica Ferr.	1933	Fiji	*Promecotheca coeruleipennis*	Introduction unsuccessful	O'Connor, 1950 *b*; Taylor 1937
Pediobius painei (Ferr.)	,,	,,	,,	,,	,,
Toxorhynchites (= *Megarhinus*) *splendens* (Wied.)	1931	,,	*Aedes scutellaris*—group	Established	Simmonds, 1932 *a*; O'Connor, 1950 *b*; Hoyt 1957
Apanteles tirathabae Wlkn.	1930	,,	*Tirathaba complexa* Btlr.	Established. Gave higher levels of parasitism than in Java	Paine, 1935; O'Connor, 1950 *b*
Telenomus tirathabae Ferr.	1931	,,	,,	Established	Paine, 1935; O'Connor, 1950 *b*

1	2	3
Argyrophylax (*Erycia*) *basifulva* (Bezzi)	1931–33	Fiji
Sturmia painei Baranov	1933	,,
Nemeritis palmaris Wilk.	1933	,,
Campsomeris javana Lep. (Hym., Scoliidae)	1935, 1936	Mauritius
C. annulata F.	,,	,,
C. quadrifasciata F.	,,	,,
C. lindenii Lep.	,,	,,
C. phalerata (Sauss.)	,,	,,
C. leefmansi Betr.	,,	,,
C. quadriguttulata Burm.	,,	,,
C. asiatica Sauss.	,,	,,
Prosena siberita (F.)	,,	,,
Urodexia uromyoides Tns. (Dip., Dixidae)	,,	,,
Chilocorus politus Muls.	1937	,,
Scymnus sp.	,,	,,
Chiloneurinus microphagus Mg. (Encyrtidae)	1938	,,
Spaniopterus crucifer Gah.	,,	,,
Comperiella unifasciata Ishii	,,	,,

TABLE II—(*Contd.*)

4	5	6
Tirathaba complexa Btlr.	Established	Paine, 1935; O'Connor, 1950 *b*
,,	Not established	,,
,,	Established	,,
Clemora smithi (Arrow)	Not established	Moutia and Mamet, 1946; Williams and Mamet, 1962
,,	,,	,,
,,	,,	,,
,,	,,	,,
,,	Established and of some control value	Moutia and Mamet, 1946; Williams and Mamet, 1962
,,	Not established	,,
,,	,,	,,
,,	,,	,,
,,	,,	,,
,,	,,	,,
Aspidiotus destructor Sign.	Very successful in controlling the scale	Moutia and Mamet, 1946
,,	Not established	,,
,,	,,	,,
,,	,,	,,
,,	,,	,,

Aphytis chrysomphali (Mercet)	1927	Fiji
Scymnus sp.	,,	,,
S. crucifer	,,	,,
C. unifasciata	,,	,,
Casca parvipennis Gahan	,,	,,
Aleurodothrips fasciapennis Frankl.	,,	,,
Ooencyrtus sp.	1937–38	Solomon Islands
O. malayensis Ferriere	,,	
Hadronotus homoeoceri Nixon	,,	
Anastatus sp. possibly *dasyni* Ferriere	,,	
Eulophid sp.	1927	Fiji
Trichogrammatoidea nana Zehnt.	,,	,,
Encarsia flavoscutellum Zehnt.	1924	Taiwan
,,	1928–30, 1954	Philippines
Sporotrichum sp. (Fungus)	1926	Hawaii
Campsomeris quadrifasciata F.	1936	Malaya
C. leefmansi	,,	,,
C. annulata	,,	,,
Anagyrus aegyptiacus Moursi (Hym., Encyrtidae)	1934–39	Egypt

,,	Established but of insignificant control value	Taylor, 1935; O'Connor, 1950 *b*
,,	Established	,,
,,	Results not known	,, ; Hoyt, 1957
Aspidiotus destructor Sign.	Not established	Taylor, 1935; O'Connor, 1950 *b*; Hoyt, 1957
,,	,,	,,
,,	Established	O'Connor, 1960 *b*
Amblypelta cocophaga China	Results not known	Phillips, 1941
	,,	,,
	,,	,,
	,,	,,
Levuana iridescens B.B.	Not established	Hoyt, 1957
,,	,,	,,
Ceratovacuna (*Oregma*) *lanigera* Zehnt.	,,	Ishida, 1929; Lopez, 1930, 1931; Takano, 1934, 1940
,,	,,	Baltazar, 1963
Rhabdoscelus obscurus (Boisd.)	Results not known	Pemberton, 1927, 1948
Anomala shanica Arr.	Not established	Corbett and Pagden, 1941
,,	,,	,,
,,	,,	,,
Pseudococcus filamentosus (Ckll.) and *Maconellicoccus hirsutus* (Green)	Established and gave satisfactory control	Kamal, 1951 *a*

1	2	3
A. kamali Moursi	1934–39	Egypt
Leptomastix phenacocci Comp. (Encyrtidae)	,,	,,
Achrysopophagus sp. (Encyrtidae)	,,	,,
Scymnus conformis Jord.	1937	,,
Telenomus spodopterae Dodd	1940	,,
Tetrastichus brontispae Ferr.	1935–36	Solomon Islands
,,	1947	New Caledonia
Diatraeophaga striatalis Tns.	1961	Mauritius
,,	1964	Malagasy
,,	,,	Reunion Is.
,,	1916	Taiwan
Spathius apicalis Westw. (Hym., Braconidae)	1949	New Hebrides
Chelonus striatigenas Cam.	1960	Fiji
Telenomus beneficiens Zehn. var. *elongatus* Ishida	1915	Taiwan
Macrocentrus homonae Nixon	1935, 1936	Ceylon
Scymnus smithianus Clausen and Berry	1930	Cuba
Scymnus apiciflavus Motsch.	1937	Kenya

TABLE II—(*Contd.*)

4	5	6
Pseudococcus filamentosus	Established and gave satisfactory control	Kamal, 1951 *a*
,,	,,	,,
,,	,,	,,
,,	,,	,,
Spodoptera litura (F.)	,,	,,
Brontispa longissima Gestro	Established	O'Connor, 1940 *b*
,,	Results not known	Hoyt, 1957
Chilo sacchariphagus Boj.	Recovered once in field	Hoyt, 1957; Ghani, 1962; Ghani and Williams, 1963
,,	Not established	Breniere *et al.*, 1966 *a* and *b*; Appert *et al.*, 1969
,,	Recovered in 1968	,,
Chilo sacchariphagus Boj.	Not established	Takano, 1940
Diocalandra taitensis Guer. (Col., Curculionidae)	Results not known	Hoyt, 1957
Nacoleia octasema (Meyr.)	Established and gave partial control	O'Connor, 1964
Scirpophaga nivella (F.)	Established and is the most important parasite of the top borer	Lee and Chiu, 1961
Homona coffearia Nietn.	Established and gave complete control	King, 1937, 1939; Gadd 1941, 1946
Aleurocanthus woglumi	Apparently became established but was of little control value	Clausen, 1934; Le Pelley, 1968
Planococcus kenyae (Le Pelley)	Not established	Greathead, 1971

TABLE. III. *Natural enemies introduced from the Philippines into other countries*

Natural enemy 1	Year of introduction 2	Introduced into 3	To control 4	Remarks 5	References 6
Gulella bicolor (Hutton)	1957	Hawaii	*Subulina octona* (Brug.)	Not established	Davis, 1958; Davis and Butler, 1964
Dactylosternum cycloides Knisch. (Col., Hydrophilidae)	1925–26	,,	*Rhabdoscelus obscurus* (Boisd.)	,,	Pemberton, 1927; Williams, 1931
D. dytiscoides F.			,,	,,	,,
D. hydrophiloides Macl.			,,	,,	,,
Colophotia praesta Eschsch. (Col., Lampyridae)	1939	,,	*Lymnaea* spp.	,,	Fullaway, 1952
Thyreocephalus albertisi (Fauvel)	1947–50	,,	Fruit-flies	,,	Weber, 1951; Clausen *et al.*, 1965
Two Coccinellid spp.	1924	Guam	Coconut scales	Established	Otanes, 1952
Coelophora inaequalis (F.)	1958	Hawaii	*Aphis gossypii* Glover	Not known if established	Davis, 1959
Coelophora sp.	,,	,,	*Aphis* spp.	,,	,,
Menochilus sexmaculatus F.	,,	,,	Aphids	,,	S. R. Capco, 1958 (Unpublished report)
Pullus sp.	1930	,,	*Saccharicoccus sacchari* (Ckll.)	Established and gave very beneficial results	Fullaway, 1952
Scymnus binotulatus Boh.	,,	,,	,,	,,	,,
Scymnus bipunctatus Kugelann	1910, 1913	U.S.A.	*Planococcus citri* (Risso)	Established but later disappeared	Smith, 1914; Quayle, 1941; Ebeling, 1950
Scymnus roepkei Fluiter	1958	Hawaii	Mealybugs	Not known if established	Davis, 1959
Aenasius advena Comp.	,,	,,	,,	,,	,,
Scymnus sp.	,,	,,	*Aphis gossypii* Gover	,,	,,
Verania crocea (Mulsant)	,,	,,	,,	,,	,,
Verania sp.	,,	,,	*Aphis* spp.	,,	,,

TABLE III—(*Contd.*)

1	2	3	4	5	6
Catharsius molossus L. (Col., Scarabaeidae)	1921	Hawaii	Horn-fly	Failed to reproduce in confinement	Fullaway, 1923
Onitis phartophus Lansb. (Scarabaeidae)	,,	,,	,,	,,	,,
Onthophagus sp.	,,	,,	Horn-fly and other Diptera	Not known if established	Williams, 1931
Anthocorid bug	1925–26	,,	*Perkinsiella saccharicida* (Kirk.)	Not established	,,
Tytthus (*Cyrtorhinus*) *fulvus* (Knight)	1937, 1938	,,	*Tarophagus proserpina* (Kirk.)	Established and gave control	Fullaway, 1952; Gardner, 1958; Pemberton, 1964
Dexia sp. (Dip., Dixidae)	1916	,,	White grubs	Not established	Williams, 1931
Prosena sp.	,,	,,	*Anomala* and *Adoretus*	,,	,,
Larvaevorid sp.	1957	,,	*Spodoptera mauritia* Boisd.	Not known if established	S. R. Capco, 1957 and 1958 (Unpublished reports)
,,	1958	,,	*Polydesma* sp.	,,	,,
Chrysopilus ferruginosus Wied.	1925–26	,,	*Rhabdoscelus obscurus* (Boisd.)	Not established	Pemberton, 1927; Williams, 1931
Syrphid spp.	1907	Australia	*Macrosiphum rosae* (L.)	,,	Jenkins, 1946; Wilson, 1960
Apanteles ruficrus Haliday	1958	Hawaii	*Spodoptera mauritia acronyctoides* (Guenee)	,,	Davis, 1960
Spathius helle (= *fuscipennis* Ashm.) (Braconidae)	1928	Japan	*Chilo suppressalis* (Wlk.)	,,	Ishii and Mizutani, 1934; Watanabe, 1958; Yasumatsu and Torii, 1968
Trichogramma sp.	1929	,,	,,	The species was found to be identical with the indigenous *T. chilonis*	Yasumatsu and Torii, 1968
Ichneumonid sp.	1922	Hawaii	*Lampides boeticus* (L.) (Lycaenidae)	Not established	Williams, 1931

Platysoma abruptum Er. (Col., Histeridae)	1925–26	,,
Paranagrus osborni Fullaway (Hym., Mymaridae)	1916	Hawaii
Ootetrastichus megameli Fullaway	1938	,,
Pediobius (= *Pleurotropis*) *epilachnae* (Rohwer)	1954	Guam
Thripoctenus vinctus Gahan (Hym., Eulophidae)	1931	Hawaii
,,	,,	Japan
Anagyrus saccharicola Timberlake (Hym., Encyrtidae)	1930	Hawaii
Aphycus timberlakei Ishii (Encyrtidae)	1909	Australia
Comperiella bifasciata Howard	1936–38	Hawaii
Scutellista sp.	1907	Australia
Pachycrepoideus vindemmiae (Rondani) (= *dubius* Ashm.)	1914	Hawaii
Spalangia philippinensis Fullaway	,,	,,
Brachymeria albotibialis Ashmead	1958	,,
Campsomeris annulata F.	1940	Mariana Islands

Rhabdoscelus obscurus (Boisd.)	Not known if established	Pemberton, 1927
Peregrinus maidis (Ashm.)	Established	Swezey, 1925; Williams, 1931
Tarophagus proserpina (Kirk.)	,,	Swezey *et al.*, 1939; Zimmerman, 1948
Epilachna philippinensis Dke.	,,	Peterson, 1956 *b*; Gardner, 1958
Thrips	Not established	Fullaway, 1952; Fullaway and Dobroscky, 1934
,,	,,	Watanabe, 1958
Saccharicoccus sacchari (Ckll.)	Established and gave substantial control	Fullaway, 1952; Pemberton, 1964
Eulecanium persicae (F.)	Widely established. The scale was effectively controlled. It is uncertain whether this establishment is attributable to Japan or the Philippines	Wilson, 1960
Aonidiella inornata McKenzie [previously mistaken to be *A. aurantii* (Mask.)]	This attacks *Hemiberlesia rapax* (Comst.) but not *A. inornata*	Swezey *et al*, 1939; Zimmerman, 1948
Coccus hesperidum L.	Not established	Wilson, 1960
Diptera	Established	Swezey, 1925; Williams, 1931
,,	,,	,,
Polydesma sp. (Lep., Noctuidae)	Not known if established	S. R. Capco (Unpublished report)
Anomala sulcatula Burm.	Established and gave complete control	Yasumatsu *et al.*, 1953

1	2	3
Campsomeris aureicollis Lep.	1931	Australia
Odynerus luzonensis Rohwer (Hym., Vespidae)	1922	Hawaii
Dolichurus stantoni Ashmead (Hym., Ampulicidae)	1916	,,
Motes subtessellatus (Smith) (Hym., Sphecidae)	1922	,,
Larra luzonensis Rohwer (Hym., Sphecidae)	1925	,,
Larra sanguinea Williams	1922	,,
Pseudaphycus orientalis Ferr. (Hym., Encyrtidae)	1937	Kenya
Platynaspis stictica philipensis Karsch. (Col., Coccinellidae)	,,	,,
Coccodiplosis smithi (Felt) (Dip., Cecidomyiidae)	1936	,,

TABLE III—(*Contd.*)

4	5	6
Dermolepida albohirtum (Waterh.) (Col., Melolonthidae)	Not liberated	Wilson, 1960
Lampides boeticus (L.)	Not established	Williams, 1931; Pemberton, 1948
Periplaneta australasiae F. (Dict., Blattidae)	Established and gave partial control	Swezey, 1925; Pemberton, 1948, 1953
Gryllus oceanicus Le Guillou (Orth., Gryllidae)	Established	Williams, 1928; Swezey, 1934
Gryllotalpa africana P. de B. (Gryllidae)	Established and gave partial control	Williams, 1931; Swezey, 1934
,,	Not established	Williams, 1928, 1931
Planococcus kenyae (Le Pelley)	,,	Greathead, 1971
,,	,,	,,
,,	,,	,,

DISCUSSION

Whilst some outstanding successes in biological control of pests have occurred in South-east Asia and the Pacific region and substantial or partial control of several other pests has also been reported only 19 of the 225 world-wide instances of more or less successful biological control of insect pests listed by DeBach (1962 and 1964) are from the area covered in this *Review*. One of these, control of the cottony-cushion scale *Icerya purchasi*, was in India, one, control of *Homona coffearia*, in Ceylon, and the remaining 17 were on various islands in the Malay Archipelago and in the Pacific. This comparatively small number of successes (less than 10 per cent of the world total) is undoubtedly due to the correspondingly small number of well-planned and adequately financed biological control projects carried out here as compared with some other areas. Fiji is certainly an exception to this general statement. This underlines the general world-wide experience noted by DeBach (1964) that over the years the successes attained in biological control of pests in any particular area are proportional to the amount of research carried out and the number and variety of beneficial species imported.

Recorded in this *Review* are the following biological control successes in addition to those listed by DeBach (1964) (C = Complete, S = Substantial, P = Partial).

Pest	*Country/territory*	*Control results*
Eriosoma lanigerum	India	P
Quadraspidiotus perniciosus	India	P
Icerya purchasi	Hong Kong	S
Plutella xylostella	Indonesia	P
Tryporyza nivella	Taiwan	P
Aspidiotus destructor	New Hebrides	C
Susumia exigua	Fiji	P
Nezara viridula	Tonga Is.	S
Achatina fulica	Guam and Mariana Is.	P

Successes in other areas with natural enemies introduced from this region:

Nomadacris septemfasciata	Mauritius	S
Gynaicothrips ficorum	Hawaii (U.S.A.)	S
Macrosiphum pisum	Canada, Hawaii	S
Antonina graminis	U.S.A.	S
Diatraea saccharalis	Barbados	C

With several other pests in or outside the region where establishment of a parasite or predator has resulted, the control obtained has not yet been assessed.

There are certainly a number of other possibilities for biological control of pests in this area which should be investigated fully. These are discussed below:

EXOTIC PESTS IN THE AREA

One of the most important and extensively distributed pests in this area is the Australian cottony-cushion scale *Icerya purchasi*, which has been controlled remarkably well by *Rodolia cardinalis* (also native to Australia) in Ceylon, Guam, Hong Kong and India. This predator has been effective against *Icerya aegyptiaca* and *I. seychellarum* (Westw.) on some of the Pacific Islands and it would be easy to introduce it wherever else these *Icerya* spp. have spread and the predator is absent.

Of the three major apple pests recorded in India and Pakistan some measure of biological control of San José scale in India and of the woolly aphid in both countries has been achieved by introducing their parasites, but the codling moth has received very little attention from the biocontrol point of view. This is a serious pest in parts of West Pakistan and in recent years it has also been recorded in the apple-growing areas of north-western India. Work in Canada and the U.S.A. with European parasites of the codling moth has not been encouraging. Several parasites of *C. pomonella* are known from Australia and a fungus, *Isaria farinosa* (Dicks.) Er. has been reported to kill large numbers of codling moth larvae in Victoria (90 per cent mortality in one area) and Tasmania (Wilson, 1960). Before the pest spreads to other areas in India where apples are grown it would be worthwhile exploring the possibilities of biological control.

The coffee berry-borer *Hypothenemus hampei* is a native of Africa, where at least three important parasites of this pest are known. Two of these, *Prorops nasuta* and *Heterospilus coffeicola*, have been introduced into Ceylon and Java without success but these may well be tried in other areas. A recently discovered Bethylid parasite, *Cephalonomia stephanoderis* Betrem, is reported to kill almost 50 per cent of the broods of *H. hampei* in the Ivory Coast (Le Pelley, 1968). This species may also be introduced into areas where the berry-borer is a problem, for example, India, Indonesia and Malaysia.

According to Mutuura and Munroe (1970) *Ostrinia furnacalis* is the common maize-feeding species of this genus in both temperate and tropical Asia and the European corn-borer *O. nubilalis* does not occur in this region. Therefore, previous records of *O. nubilalis* from Guam and the Philippines and the parasite introductions made into these areas pertain to *O. furnacalis*. In India the latter species has been reared from *Polygonum* sp. but not from maize. Parasites of *O. furnacalis* should be investigated in areas where this has not as yet been done so that the possibilities of biological control may be fully explored.

In Fiji biological control of *Nezara viridula*, a native of the U.S.A., which is a widespread and polyphagous pest in this region, has not been successful, although the introduced egg parasite *Asolcus basalis* has become established. This Scelionid has controlled the bug in Tonga. In the Cook Islands the small number of four adults released was inadequate for establishment to occur and if further releases are made there would be good chances of establishment and of control of the pest.

Several species of insect pests which have a restricted distribution in the Malay Archipelago and the Pacific territories seem to occur naturally on certain isolated island groups without effective parasites or predators to check them, or else they have accidentally spread to these islands unaccompanied by their natural enemies. Biological control of some of these, for example, *Homona coffearia*, *Promecotheca* spp. and *Brontispa* spp., by introducing parasites from other areas has been spectacular. With *Levuana iridescens* in Fiji completely successful control resulted from the introduction of a parasite, not of the same pest but of a different one, *Artona catoxantha*, from Malaysia. This and several other similar examples listed by Pimentel (1963) warrant the hope that certain pest species in this region which are not kept in check by their own natural enemies, either indigenous species or those introduced from other areas, may well be controlled by parasites of other insects with similar habits, occupying comparable ecological niches, etc. It is possible that *Nephantis serinopa*, a serious pest of coconuts in Ceylon and India, may be controlled by introducing parasites of *Agonoxena argaula* and that some of the several parasites of *Nephantis* may similarly be of value against *Agonoxena* in Fiji.

According to Wilson (1963) the genus *Amblypelta* is confined to Australia and some islands to the north. The only parasite introduced, though unsuccessfully, from Australia into the Solomon Islands to control *A. cocophaga* was the Tachinid *Pentatomophaga bicincta*. Additional parasites of *Amblypelta* spp. from the Australian region should be given a trial in the Solomons. In East Africa some species of the closely related genus *Pseudotheraptus* cause serious damage to coconuts. It would, therefore, be desirable to explore further the possibilities of biological control of both *Amblypelta* and *Pseudotheraptus* in these widely separated areas by introducing natural enemies from one to the other.

Recent reports on the use of *Rhabdionvirus oryctes* against the coconut Rhinoceros beetle in Western Samoa under a project jointly sponsored by the United Nations Development Fund and the South Pacific Commission have been promising, but it is very unlikely that the pest would be satisfactorily controlled by this virus alone in various areas. Several predators of *O. rhinoceros* have been investigated in India and these should be given further trials together with the Reduviid *Platymeris laevicollis*.

Stem-borers are major pests of rice, sugarcane, maize and other cereal crops in south-east Asian countries, notably Ceylon, India, Indonesia, Malaysia, Pakistan, and the Philippines. These have a very large complex of parasites and yet the over-all control exerted by the native parasites is not enough to prevent serious economic losses. Several important parasites of *Chilo* spp. and other graminaceous stem-borers have been investigated by CIBC in East Africa (Mohyuddin and Greathead, 1970). These are recommended for trial in south-east Asian countries. Similarly, parasites of graminaceous stem-borers from these countries should be given adequate trials in Africa and in the New World. The introduction of *Apanteles flavipes* from India into Barbados has proved to be an outstanding economic success in controlling *Diatraea saccharalis* and this merely emphasizes the fact that some species of parasites may have an immense control potential, even against related species, which is actually realised only under certain ecological conditions and which it is difficult to foresee or define in precise terms. Ultimately, actual introduction and field trial of parasite or predator on an adequate scale are the only arbiters of success or failure in a biological control programme, though it is reasonable to expect that a detailed study of the pest and its natural enemies would be of considerable value before any selections for introduction are made.

Several parasite introductions against *Necoleia octasema* and *Agonoxena argaula* into the Solomon Islands have not been successful from the economic standpoint, although with the former pest some species of parasites became established. It is possible that the presence of several alternative hosts reduces the control value of these parasites against the scab-moth in Fiji. Some of these parasites are worth introducing into Tonga where they may prove more effective.

The cotton leaf-roller *Sylepta derogata* (F.) occasionally causes serious damage in India and Pakistan. In parts of the Sudan *Apanteles syleptae* Ferr. and other parasites have been found to give 70–90 per cent parasitism of the leaf-roller population (Schmutterer, 1969). These may prove effective in controlling not only *S. derogata* on cotton but also other *Sylepta* spp. attacking various other cultivated Malvaceae elsewhere in this region.

Le Pelley (1968) considers that biological control of two coffee pests, *Xylosandrus compactus* (Eich.) (= *Xyleborus morstatti* Hag.) and *Xylotrechus quadripes* Chev., is worth attempting. Some parasites of the former are known in Indonesia, and several important ones of the latter in Indo-China, where, however, mass-breeding and liberation of indigenous parasites has not proved effective. These parasites may be more effective in other ecological situations.

COSMOPOLITAN PESTS

Many pests which have been the targets of biological control in this area are more or less cosmopolitan in distribution and some are attacked by various local parasites and predators. *Cosmopolites sordidus*, the banana weevil, is a well-known and widely distributed pest for which no really effective natural enemies have been found to date. Predators introduced from Java and the West Indies into various other areas have given little or no control, but it is possible that more extensive search in as yet unexplored areas might yield valuable additional biocontro agents.

Plutella xylostella (= *maculipennis*) has several important hymenopterous parasites and two virus diseases and the prospects of biological control appear good. However, the indiscriminate use of broad-spectrum contact insecticides against it in many areas prevents the successful utilisation of biocontrol agents.

The potato tuber moth, *Phthorimaea operculella*, of South American origin, is primarily a pest of potatoes but can damage tobacco, brinjal and tomato plants. Following releases, four species of South American parasites and one from Cyprus have been recovered at two liberation sites in south India. Further releases of exotic PTM parasites should be made in other parts of India and elsewhere in this region. Parasites of *P. operculella* may also be of value against *Phthorimaea heliopa* (Low.) and other related species. *P. heliopa* is an important pest of tobacco in Ceylon, Fiji, India, Malaysia, Samoa, etc. (Evans, 1952).

The coconut scale *Aspidiotus destructor* has been very effectively and economically controlled in many parts of the world [Fiji, Mauritius and Principe (West Africa)] by introduced Coccinellid predators, chiefly *Cryptognatha nodiceps*. If this scale assumes 'pest status' in any other area, either on coconuts or on other hosts, where these predators are absent they could easily be introduced.

Ferrisia virgata is a polyphagous pest of citrus, cocoa, coffee, jute, etc., in South-East Asia, and the Pacific. In East Africa it is reported to be heavily attacked by *Gyranusa citrina* Compere and unidentified Encyrtids, and there are several known predators, which together generally keep the pest population low (Le Pelley, 1968). These natural enemies are well worth introducing into this region. There are several other citrus pests in the region, *e.g.*, *Parlatoria pergandii* Comst., *Phyllocoptruta oleivora* (Ashm.), *Aleuroplatus samoanus* Laing and *Toxoptera* spp., for which possibilities of biological control exist and these should be investigated.

Cryptolaemus montrouzieri is reported to be ineffective in controlling the sugarcane mealy-bug *Saccharicoccus sacchari* because of its failure to reach its prey under the leaf-sheaths of the sugarcane. There are a number of parasites and predators of this mealy-bug in both the Old and the New Worlds (Dick, 1969). It would be desirable to introduce these from one area into the other.

Biological control of species of *Agrotis*, *Heliothis* and *Plusia*, which have a world-wide distribution, has received scant attention. Each has a complex of parasites which merit consideration for introduction from one area into another where there is a definite need for additional natural enemies. Parasites and predators of *H. armigera* have been investigated in India and the more important of these, such as the Ichneumonid *Ecphoropsis perdistinctus*, can be introduced into the Pacific area.

The giant African snail *Achatina fulica* continues to cause serious concern in many areas, such as India (both on the mainland and in the Andaman Islands) and Malaysia. *Gonaxis* spp. have become established in Ceylon, the Mariana Islands and Sabah (East Malaysia). In Sabah *G. quadrilateralis* has only recently become established following the release of only a few individuals. More releases should be made in different areas and it is as yet too early to judge the results. Whilst the impact of the predator on the *Achatina* population in Ceylon has not been assessed, reports from the Mariana Islands indicate some beneficial results. Efforts to introduce both *Gonaxis* and *Euglandina* into Hong Kong and India have not been successful. In both areas imported stocks of predacious snails were available for release only when the giant African snail was in an inactive period and the releases did not, therefore, synchronise with periods of prey activity and abundance.

INDIGENOUS NATURAL ENEMIES IN BIOLOGICAL CONTROL

There are two aspects involved in the use of indigenous parasites and predators in biological control. The first is the artificial distribution of some native species from one area to another where these do not naturally occur, the two areas being separated by geographical or ecological barriers (sea, high mountain ranges, desert zones, etc.). Wilson (1960) has mentioned several instances of such transfer of native natural enemies from one State to another in Australia. The transfer of a native natural enemy from one part of the same country or territory to another separated by geographical or ecological barriers is comparable with the introduction of an exotic species from an alien habitat. In Indonesia attempts have been made to control *Aspidiotus destructor* and *Brontispa longissima* by spreading their natural enemies from one part of the country to another. The second aspect concerns the practice of mass-breeding one or more species of parasite or predator of a pest in an area where these are already present and releasing them periodically in the same area to increase their populations in an effort to obtain additional control of the pest. With this method the results have in general been very disappointing considering the number of years over which mass-breeding and release programmes have been carried out and the expenditure incurred in maintaining the necessary parasite breeding laboratories. In India mass-releases of indigenous parasites against *Nephantis* and sugarcane borers by local agencies have been going on for over two decades. Mass-releases of native parasites of cotton boll-worms, *Epilachna* sp. and the sugarcane leaf-hopper *Pyrilla* (with which parasites were merely reared from field—collected host material and released in large numbers) have at best only temporarily raised the levels of parasitism. Results with native parasites of *Xylotrechus quadripes* in Indo-China have been similar.

THE USE OF INSECT PATHOGENS

Pathogenic organisms have been little used in biological control in this area. A nuclear polyhedral virus of *Plutella xylostella* has to date shown promise in limited tests in India and warrants large-scale trials. *Bacillus thuringiensis* and *Metarrhizium anisopliae* have also been tested on various insect pests in this region but neither has been used effectively on a large scale to give economic control of any pest.

Recently *Cephalosporium aphidicola* sent to England from India has been tested against *Aphis gossypii* with promising results. The brown fungus *Aegerita webberi* introduced from India and widely distributed in Florida, U.S.A., appears to have failed to control *Dialeurodes citri.*

On the whole much remains to be done on microbial control of insect and other pests in this region.

BIOLOGICAL CONTROL OF WEEDS

Prickly pears (*Opuntia* spp.) have been very successfully controlled over large areas in this region by introducing their natural enemies originating from South America. *Lantana camara* is widespread in the region, but Fiji is again the only country which has made any sustained attempts at biological control. Several species of *Lantana* insects of New World origin have been introduced there and some are now being spread to the Cook Islands, Tonga, etc., but the over-all control of *Lantana* is still unsatisfactory and other introductions are contemplated. Several additional *Lantana* insects are now available and should be tried.

Natural enemies of *Xanthium strumarium* and *Cuscuta* spp. have been studied at the CIBC Pakistan Station and these may be given a trial in other areas within and outside the regiont *Nupserha antennata* introduced into Australia from India is well-established there and its effects on the weed are being investigated. This should also be tried in other areas in the Pacific.

The possibilities of biological control of other terrestrial weeds, such as *Cyperus rotundus*, *Cordia macrostachya* (Jacq.), *Eupatorium odoratum*, *Imperata cylindrica* (L.) and *Mikania* spp. which are important in various South-east Asian countries and on some of the Pacific Islands are being considered. In Sabah (East Malaysia) a leaf-feeding Arctiid *Ammalo insulata* Wlk. and a weevil, *Apion brunneonigrum* B.-B., whose larvae feed on the achenes and adults on other different parts of the plant, have recently been introduced from Trinidad against *E. odoratum*. Insects attacking *C. rotundus* have been studied in India and Pakistan, where

Bactra spp. and the weevil borer *Athesapeuta cyperi* are important insect enemies of nutgrass and these may be useful in other areas. Biological control of *C. macrostachya* has been extremely successful in Mauritius, following the introduction of a leaf-feeding Chrysomelid, *Schematiza cordiae* Barb. and a seed-feeding Chalcid, *Eurytoma attiva* Burks., from Trinidad (Simmonds, 1967). These may be introduced into Malaysia. Investigations on natural enemies of *Imperata* should be made in Africa and other areas. Practically nothing is known of the natural enemies of *Mikania* spp. most of which occur in the New World. These should be investigated and may prove useful against *Mikania* spp. in India, Malaysia, etc.

As regards aquatic weeds, the water-hyacinth *Eichhornia crassipes* (Mart.) Solms. and the water-fern *Salvinia auriculata* Aubl. are of major economic importance in Ceylon, India, Indonesia, Malaysia, Thailand and other areas. Several host-specific natural enemies of these two weeds are known in Central and South America (Bennett, 1966–68; Bennett and Zwolfer, 1968). Their introduction into South-east Asian countries is worth considering.

SOUTH-EAST ASIA AND THE PACIFIC REGION AS A SOURCE OF BENEFICIAL INSECTS

A large number of species of parasites and predators have been shipped from this region to other areas and several have also been transferred within the region. Some of these introductions have been successful as already discussed earlier in this section. Other notable and successful introductions were against *Oxya chinensis*, *Nipaecoccus vastator*, *Perkinsiella saccharicida*, *Pinnaspis buxi* and fruit-flies in Hawaii, *Aonidiella aurantii*, *Chrysomphalus ficus* and *Parlatoria oleae* in the U.S.A., *C. ficus* in Israel, *C. ficus*, *P. buxi* and *Ischnaspis longirostris* in the Seychelles, *Pseudococcus filamentosus* and *Maconellicoccus hirsutus* in Egypt, *Aspidiotus destructor* in Mauritius and the Seychelles and *Aleurocanthus woglumi* in Mexico, the West Indies, parts of Central America, the Seychelles, East and South Africa.

In the region there are several exotic pests attacked by local natural enemies which may be of value in other areas. For example, in Pakistan, the San Jose scale, which is thought to be a native of China (Wilson, 1960), is commonly attacked by an *Aphytis* sp. (*proclia* group). This was shipped to Russia and became established, giving significant control in one area. *P. saccharicida*, *Saccharicoccus sacchari* and *Rhabdoscelus obscurus* are of Australian origin (Wilson, 1963). Natural enemies of the first two species and of borers related to *R. obscurus* have been shipped to Hawaii.

There are promising possibilities for introducing additional and more effective natural enemies of certain pests from one country or territory to another within this region. These have to be fully explored. An example is *Planococcus lilacinus*, which has several important parasites and predators in Indonesia and the Philippines (Le Pelley, 1943). Some of these appear to be more effective in reducing the mealy-bug populations than the species known from Ceylon and India.

With the fast-expanding volume of international trade and traffic the chances of insects and other pests spreading to new areas have greatly increased. The recent discovery of the coconut leaf-miner *Promecotheca cumingi* in Ceylon (U. B. M. Ekanayake, pers. com., 1971) is an example of such a situation.

Natural enemies of Coccids, aphids, Aleurodids and other plant bugs have received special attention in the search for biological control agents in this region. Parasites of graminaceous stem-borers and fruit-flies have also been extensively investigated in various parts of South-east Asia. Some of these may prove to be effective in other ecological situations.

Very little work has been done in this region on natural enemies of insect pests of medical and veterinary importance. Recent surveys for natural enemies of house-flies and other related flies in India and Pakistan have shown that some species of parasites play an important role in restricting host abundance and these may be useful in other areas where they do not occur. Investigations on natural enemies of Triatomids are now in progress in Singapore, India and Pakistan.

There would, therefore, appear to be ample scope for further biological control work in the region in all aspects—the introduction of additional natural enemies from other areas against pests in the region, the discovery, study and shipment of beneficial species from the region elsewhere, and the movement from one part of the region to another of such species.

The comparative lack of sustained efforts to utilize biological control more extensively in the region is no doubt responsible for the few successes achieved here. However, the situation in the past in Fiji has been economically very rewarding, and such economic benefits could well be achieved in other areas.

It is hoped that a consideration of the facts and suggestions given in this volume will stimulate additional interest and activity in the field of biological control in the region.

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